ACTA UNIVERSITATIS SZEGEDIENSIS

ACTA BIOLOGICA

NOVA SERIES

TOMUS XXVII FASCICULI 1—4

SZEGED (HUNGARIA)
1981

ACTA UNIVERSITATIS SZEGEDIENSIS

ACTA BIOLOGICA

NOVA SERIES

TOMUS XXVII FASCICULI 1—4

SZEGED (HUNGARIA)
1981

Adjuvantibus
L. BOROSS, L. FERENCZY, ERZSÉBET KÖVES, L. MÓCZÁR, L. OROSZ, P. SIMONCSICS, L. SZALAY

redigit
GYULA FARKAS

editionem curat
GY. BODROGKÖZY

edit
Facultas Scientiarum Naturalium Universitatis Szegediensis de Attila József nominatae

Nota
Acta Biol. Szeged.

Szerkeszti
FARKAS GYULA

a szerkesztőbizottság tagjai
BOROSS L., FERENCZY L., KÖVES ERZSÉBET, MÓCZÁR L., OROSZ L., SIMONCSICS P., SZALAY L.

szerkesztőbizottsági titkár
BODROGKÖZY GY.

Kiadja
a Szegedi József Attila Tudományegyetem Természettudományi Kara
(Szeged, Aradi vértanúk tere 1)

Kiadványunk rövidítése
Acta Biol. Szeged.

ISSN 0563-0592

Acta Biologica Szeged. 27 (1—4), pp. 3—7 (1981)

THE EFFECT OF PESTICIDES ON THE PROTEOLITIC ENZYME ACTIVITY OF FISHES

Department of Biochemistry, Attila József University, Szeged
(Received September 12, 1980)

J. NEMCSÓK and L. BOROSS

Summary

Studies were carryed on regarding the effect of paraquat, (1,1' – -dimethyl — 4,4'-bipiridilium) $CuSO_4$ and $ZnCl_2$ on the proteolitic enzyme activity of fishes with different nutritional habits. Paraquat, $CuSO_4$ have strongly decreased the proteolitic enzyme activity in all investigated fish species (carp, silver carp and wells).

$ZnCl_2$ did not change significantly the enzyme activity. According to our results paraquat and $CuSO_4$ damaged seriously the normal activity of proteolitic enzymes even at low concentration, so they might have adverse effect on the developing and growth of fishes. Therefore the using up of these chemicals should be restricted to that fields of agriculture which can be found far from the lakes and rivers.

Introduction

During the last two decades the widespread use of pesticides in agriculture has increased. These chemicals through the rain are getting into the natural waters, where they are rapidly accumulated in different organisms living in water, especially in fishes. The effect of several antropogenic agents on the physiological and biochemical processes of fishes are for a long time investigated. These research works were mainly focused on the demonstration of damage of nervous system (SCHRECK et al., 1978, NAKONO and TOMLINSON, 1967) liver, kidney and gills (BELL, 1968; REICHENBACH-KLINKE, 1972). Several authors has already published papers about the digestive enzymes of fishes (KAWAI and IKEDA 1971, 1972, 1973; KITAMIKADO and TACHINO, 1960; NAGOSE, 1964, ONISHI and MURAYAMA, 1970). However these works are dealing with the seasonal changes, and the distribution of proteolitic enzyme activity in different organs of fishes (SAUERBIER and MEYER, 1978) and their kinetic properties (JÓNÁS et al., 1980).

So far there was not focused research work investigating the effect of environmental pollution on the digestive enzymes of fishes.

The aim of our work was to carry out studies regarding the effect of different environmental pollutant on the proteolitic enzymes in fish species with different nutritional habits.

Materials and Methods

Common carp (*Cyprinus carpio* L.) silver carp (*Hypophthalmichthys molitrix V.*) and wells (*Silurus glanis L.*) of 350—400 g were obtained from Fisheries Research Institute in Szarvas and held as it was published before (NEMCSÓK et al, 1980). Due to the Hungarian data, in permanent metal and pesticide polluted water, these chemicals might accumulate in different fish organs (muscle, fatty tissue) up to 10 ppm. Regarding this fact the treatment was carried out with 10 ppm paraquat (1,1'-dimethyl-4,4'-bipiridilium) $CuSO_4$ and $ZnCl_2$ respectively. The length of exposition was 2 hours.

The determination of proteolitic enzyme activity

The alimentary canals of fishes were removed and homogenized in 0,1 M pH 7,5 cold (5 °C) phosphate buffer in 5 ml/g dilution. The homogenate was centrifuged at 3000 g for 30 minutes. The supernatant was used as crude extract.

Total activity was determined by the method of ANSON and KUNITZ on denaturated haemoglobin substrate. Activity was calculated on the basis of the tyrosine content of peptides produced in 1 minute by proteolysis in the TCA supernatant. 1 μM tyrosine was taken as unit. The reaction mixture consisted of 0,9 ml substrate solution in 0,1 M phosphate buffer at pH 7,9, and 0,1 ml crude extract. Digestion was stopped with TCA at O, 5th and 15th minutes.

After standing for 10 minutes, theprecipitate was removed by centrifugation. The extinction was measured at 280 nm. For the evaluation of data tyrosine calibration curve was used. The data was given in percent of the controls.

Results and discussion

The effect of paraquat on the proteolitic enzyme activity

Paraquat has markedly decreased the proteolytic enzyme activity in all fishes (Fig. 1). The decrease of activity was at 1 ppm 10—20% and at 10 ppm 60—70%. These changes were about similar in each fish species.

At the highest paraquat concentration — which effected for 10—15 minutes only, because fishes were died within this time — there was not any changes in fishes regarding the proteolitic enzyme activity.

The effect of $CuSO_4$ and $ZnCl_2$ on the proteolytic enzyme activity

$CuSO_4$ has decreased the proteolytic enzyme activity in all investigated fishes already at 1 ppm.

The most significant decrease can be seen in wells (25%) and in carp (15%). There was only a slight change in silver carp (5%).

At 10 ppm $CuSO_4$ there was a remarkable decrease also in wells. However at this concentration the proteolitic enzyme activity decreased markedly (50%) in carp and silver carp as well (Fig. 2). 100 ppm $ZnCl_2$ — which is 10 times higher comparing to the highest $CuSO_4$ concentration used during our treatment — caused only 20—30% decrease of the activity. Comparatively this degree of decrease was about the same at 100 times lesser $CuSO_4$ concentration.

Due to our results the proteolitic anzyme activity after the paraquat, $CuSO_4$ and $ZnCl_2$ treatment has changed differently.

Paraquat caused the most significant decrease, and after $ZnCl_2$ treatment there was only a shight change regarding the proteolitic anzyme activity in all investigated fish species.

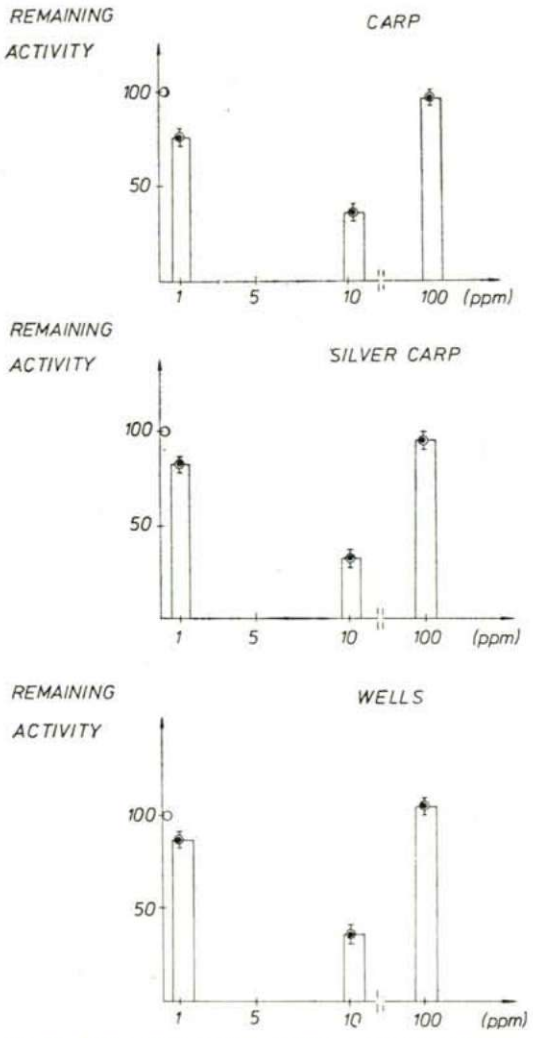


Fig. 1. The effect of 1, 10 and 100 ppm paraquat on the proteolitic enzyme activity of carp, silver carp and wells. Water temperature 20±1 °C. The values are the average of 3—9 fishes and expressed in the percent of the control ones. Exposition time 2 hours, except at 100 ppm paraquat (10—15 min.).

REICHENBACH—KLINKE (1972) reported 20—35% decrease of proteolytic enzyme activity in trout after 0,1—0,5 ppm $CuSO_4$. In our experiments such changes could be registered at higher (10 ppm) $CuSO_4$ concentration only.

The reason of this two different data might be due to the sensitivity of different fish species and the different exposure to $CuSO_4$ pollution.

We have found that the Cu^{2+} reduced the proteolytic activity of these fish species. Though it is known that the Cu^{2+} ions accelerate the oxidation of SH-groups of pro-

teins, in our cases the inhibiting effect of this metal ion may be taken as a secondary effect followed by the changes in metabolic provesses after Cu^{2+} treatment of fishes rather than a direct action on the active centre of these enzymes, because as it was shown earlier (JÓNÁS et al., 1980) these enzymes were not SH-type proteases.

$ZnCl_2$ up to 10 ppm has not changed significantly the proteolitic enzyme activity in investigated fishes.

Presumably $ZnCl_2$ is not toxic for this enzyme in this concentration range. It was published by other outhors that Zn is lesser toxic for fishes than that of the Cu

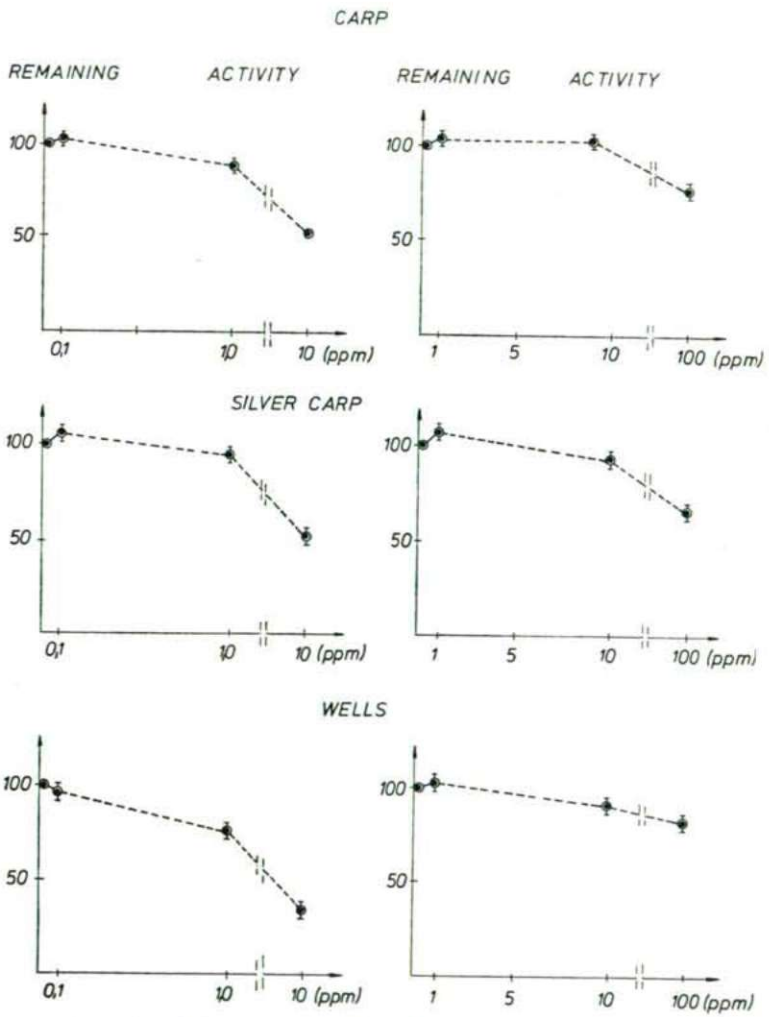


Fig. 2. The effect of 0,1, 1 and 10 ppm $CuSO_4$ (left) and 1, 10, 100 ppm $ZnCl_2$ (right) on the proteolitic enzyme activity of carp, silver carp and wells.

(MOLNÁR and SZAKOLCZAY, 1973). It was observed as well, that Zn was able inhibiing or decreasing the toxic effect of other metals (FINELLI and EL-GAZZÁR, 1977).

According to our findings, paraquat and $CuSO_4$ damaged seriously the normal functions of proteolitic enzymes even at low concentration so they might have adverse effect on the developing and gowth of fishes. Therefore the using up of these chemicals should be restrieted to that fields of agriculture which can be found far from the lakes and rivers.

References

BELL, G. R. (1968): Distribution of transaminases (aminotransferases) in the tissue of Pacific salmon *(Oncorhynchus)*, with emphasis on the properties and diagnostic use of glutamic-oxalacetic transaminase. — J. Fish. Res. Board Can. *25*, 1247—1268.

FINELLI V. N. and EL-GAZZAR R. M.: Interaction of lead an zine on the prothrombin activity in rats. — Toxicology Letters *1*, 33—39.

JÓNÁS, E. RAGYANSZKY, M., OLÁH, J. and BOROSS, L.: Comparative studies on the proteolytic digestive enzymes of carnivorous *(Silurus glanis* L.*)*, herbivorous (*Hypophthalmichthys molitrix* VAL.) and omnivorous (*Cyprinus carpio* L.) fishes. (In press).

KAWAI, S. and IKEDA, S. (1971): Studies on digestive enzymes of fishes-I. Carbohydrates in digestive organs of several fishes. — Bull. Jap. Soc. Scient. Fish. *37*, 333—337.

KAWAI, S. and IKEDA, S. (1972): Studies on digestive enzymes of fishes-II. Effect of dietary change on the activities of digestive enzymes in carp intestine. — Bull. Jap. Soc. Scient. Fish. *38*, 265—270.

KAWAI, S. and IKEDA, S. (1973): Studies on digestive enzymes of fishes-IV. Development of the digestive enzymes of carp and black sea bream after hatching. — Bull. Jap. Soc. Scient. Fish. *39*, 877—881.

KITAMIKADO, M. and. TACHINO, S. (1960): Studies on the digestive enzymes of rainbow trout-II. Proteases. — Bull. Jap. Soc. Scient. Fish. *26*, 685—690.

MOLNÁR K. és SZAKOLCZAI J. (1973): Halbetegségek — Mezőgazdasági Kiadó, Budapest, (In Hungarian).

NAGOSE, G. (1964): Contributon to the physiology of digestion in *Tilapia mossambica* PETERS: Digestive anzymes and the effects of diets on their activity. — Zeit. Vergl. Physiol. *49*, 270—284.

NAKONO, T. and TOMLINSON, H. (1967): Catechol-amino and carbohydrate concentrations in rainbow trout *(Salmi gairdneri)* in relation to physical disturbance. — J. Fish. Res. Board Can. *24*, 1701—1715.

ONISHI, T. and MURAYAMA, S. (1970): Studies on enzymes of cultivated Samonoid Fishes. II. Actii vities of protease, amylase, arginase GPT and GOT in various growth stages. — Bull. Toka-Reg. Fish. Res. Lab. *63*, 123—132.

REICHENBACH-KLINKE, H. H. (1972): Histologische und enzymatische Veränderungen nach Schadstoffeinwirkung beim Fisch. — Veröffent. Int. Küs. Einnenfischerei, Hamburg, *53*, 113—120.

SAUERBIER, J. and MEYER, W. (1978): Circadian study on certain enzyme activities in the liver of the common goldfish (*Carassius auratus* L.) — Zool. Jb. Physiol. *82*, 134—140.

SCHRECK, C. B. and LORZ, H. W. (1978): Stress response of coho salmon (Oncorhyschus Kisutch) elicited by cadmium and copper of stress. J. Fish. Res. Board Can. *35*, 1124—1129.

NEMCSÓK, J., BENEDECZKY, I., BOROSS, L., ASZTALOS, B. and ORBÁN, L. (1980): Subcellular localization of transaminase enzymes in fishes and their significance in the detection of water pollution. — Acta Biol. Szeged. (for publication accepted)

Address of the authors:

Dr. J. NEMCSÓK
Prof. Dr. L. BOROSS
Department of Biochemistry
A. J. University, H-6701 Szeged
P. O. Box 428. Hungary

Acta Biologica Szeged. 27 (1—4), pp. 9—15 (1981)

SUBCELLULAR LOCALIZATION OF TRANSAMINASE ENZYMES IN FISHES AND THEIR SIGNIFICANCE IN THE DETECTION OF WATER POLLUTION

J. NEMCSÓK, I. BENEDECZKY*, L. BOROSS, B. ASZTALOS and L. ORBÁN

Department of Biochemistry, Attila József University, Szeged;
**Biological Research Institute of Hungarian Academy of Sciences, Tihany*
(Received September 12, 1980)

Summary

On the basis of our cytochemical experiments, it can be established that the method described for demonstration of transaminase in mammalian species is also applicable in the carp liver without modification.

The distribution of transaminase activity in different organs of carp (expressed as U/l) was the following: liver GOT and GPT 149 ± 55 and $311{,}2 \pm 6{,}8$ heart: $58{,}4 \pm 13$ and $4{,}4 \pm 1{,}5$; kidney: $25{,}6 \pm 6{,}8$ and $12{,}3 \pm 3{,}2$; gills: $59{,}7 \pm 8{,}5$ and $6{,}6 \pm 1{,}9$.

Paraquat caused very serious tissue damage in each investigated fishes, but the degree of if was depending on the species. The main target of paraquat is presumably the gills membrane with disturbing effect on oxidative biochemical processes depending on the specific O_2 demand of the fish species.

Introduction

In human diagnosis the detection of injuries of liver, kidney and muscle tissues by determination of transaminase activity in blood is a commonly used well proved method. Transaminases are located in cytoplasma and in mitochondria under normal conditions. The damages and lysis of the cells result an getting these enzymes in blood in relatively high quantities. This causes a rapid increase of enzyme activity „blood transaminase". The results of some laboratories drow the attantion to the possibility to indicate the tissue injuries in some fish species, caused by pollutions of their environment, by determination of changes in blood transaminase enzyme activity.

The aim of our work was to carry out comparative studies regarding the changes of blood transaminase activities after tissues damaging effects in fish species of different nourishment, i.e. in herbivorous, in carnivorous and in mixed nourishing species.

In our experiments paraquat was used as damaging agent, the effective substance of some commercial herbicides as GRAMOXON and GROMEX.

Materials and methods

Cammon carp, (*Cyprinus carpio* L.) silver carp *(Hypophthalmichtys molitrix V.)* and wells *(Silurus glanis L.)* of 350—400 g were obtained from Fisheries Research Institute in Szarvas and held for a minimum of 7 days before experimentation in 100 litre aquaria (5 fishes per aquarium) at a tempera-

ture of 20±1 °C. The length of the exposition to 1 and 10 ppm paraquat was 2 hours and at 100 ppm 10—15 minutes, because during this time all of the treated animals were died after the treatment. The detection of injuries of different tissues was carryed out by the determination of transaminase activity in blood.

Determination of GOT (glutamate-oxaloacetat transaminase) and GPT (glutamate-pyruvate-transaminase) activities:

Reaction mixture for GOT: 0.25 ml 0,1 M pH=7,4 phosphate buffer containing 0,1 M L-aspartat and 2 mMα-ketoglutarate +0,050 ml blood serum. (0.050 ml dest. water in blank).

Reaction mixture for GPT: 0.25 ml 0,1 M pH=7,4 phosphate buffer containing 0,2 M DL-alanin and 2 mMα-ketoglutarate +0.05 ml blood serum (0,05 ml dest. water in blank).

After 60 min. incubation (30 min. for GPT) at 37 °C to each samples 0,25 ml 1 mmol 2,4-dinitrophenyl-hydrazin was added and the mixture was incubated for 20 min. at 20 °C.

After the addition of 2,5 ml 0,4 M NaOH solution the extinction was measured at 540 nm.

Cytochemical demonstration of the glutamate oxalacetate transaminase

For cytochemical investigations carp liver was used. Fixation was carried out in modified KARNOVSKY-solution (1965) for 60 min., at 40 °C. After fixation, the tissue blocks were washed for two hours in a sucrose containing buffer solution (0.2 M imidazole pH 7.4), with several changes of solution at 4 °C. The last washing was performed at room temperature. Blocks were incubated according to LEE (1973) at room temperature for 30 min with continuous shaking. The final composition of the incubation medium was the following:

l-aspartic acid	20 mM
α-ketoglutaric acid	2—4 mM
Pb $(NO_3)_2$	6 mM
imidazol	50 mM
sucrose	0,25 mM

During incubation electron dense lead acetate precipitate was developed at places where GOT was present in cellular compartments. Two kinds of controls were used in our experiments: in the first case, α-katoglutaric acid was omitted from the incubation medium, in the second one, d-aspartic acid (the inactive isomere) was applied in the incubation medium.

After incubation a postincubation rinse was done in l-aspartic acid and sucrose containing buffer solution for 30 min.

Postfixation was carried out in 2% OsO_4 for 2 hrs and blocks were embedded into Spurr's medium (SPURR, 1969).

Results and discussion

The distribution of transaminase activity (expressed as U/l) in different organs of the carps are the following: liver GOT and GPT: 149±55 and 31,2±4,5; heart: 58,4±13 and 4,4±1,5; kidney: 25,6±6,8 and 12,3±3,2. The relative high GOT and GPT activities (59,7±8,5 and 6,6±1,9) in gills can reflect, that the increase of activity in blood serum might be due to the damage of gills as well.

The GOT activity in blood serum is differing according to the species (carp 15,8± ±1,7; silver carp 12,3±1,0; wells 20±4,2). The GPT activity of carp and silver carp is about the same (2,9±0,6 and 2,7±0,4) and in wells is the highest (4,9±0,6). The blood serum transaminase activity of the three investigated fish species after 1 and 10 ppm paraquat treatment changed differently. The order of increase of GOT was the following: silver carp > carp < wells (Fig. 2.a, b, c).

The GPT activity in the three species was more significant after the paraquat treatment.

The order of increase of GPT activity was: carp<wells<silver carp. There was no significant changes after the 100 ppm paraquat treatment regarding the three investigated fish species.

The reason of it might be due to the rapid fish dying after the treatment because paraquat could not cause tissue damaging effect yet within such a short time.

The increase of transaminase activity after 1 and 10 ppm paraquat reflecting the serious damage of tissues. The slight increase of GOT activity of wells over the control, refers to the fact that the tissue damage is not so significant comparing to the other two species.

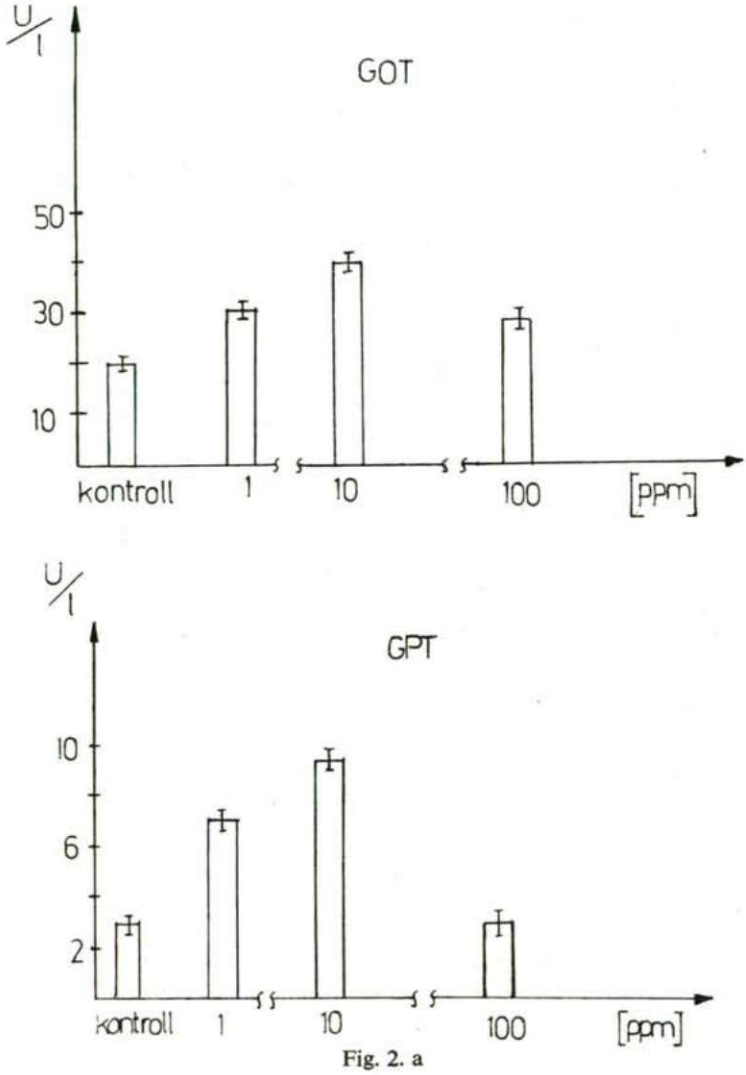


Fig. 2. a

To decide the organ specific damage of paraquat the electronmicroscopic investigations of liver, gills and kidney are in progress in our laboratory.

Many references are to be found in the literature that paraquat exerts its effect as an electron donor, transforms molecular oxygen to active radicals, which are responsible for the membrane destruction (BLOCK, 1979; STANCLIFFE and PIRIE, 1971). In clinical examination was observed lung membrane damage due to the paraquat exposure, which caused difficult breathing (CLARK et al., 1966, FISHER et al., 1971).

On the basis of our experiment the detection of transaminase activity in blood serum is a suitable tool for the detection of tissue damage. The transaminase activity

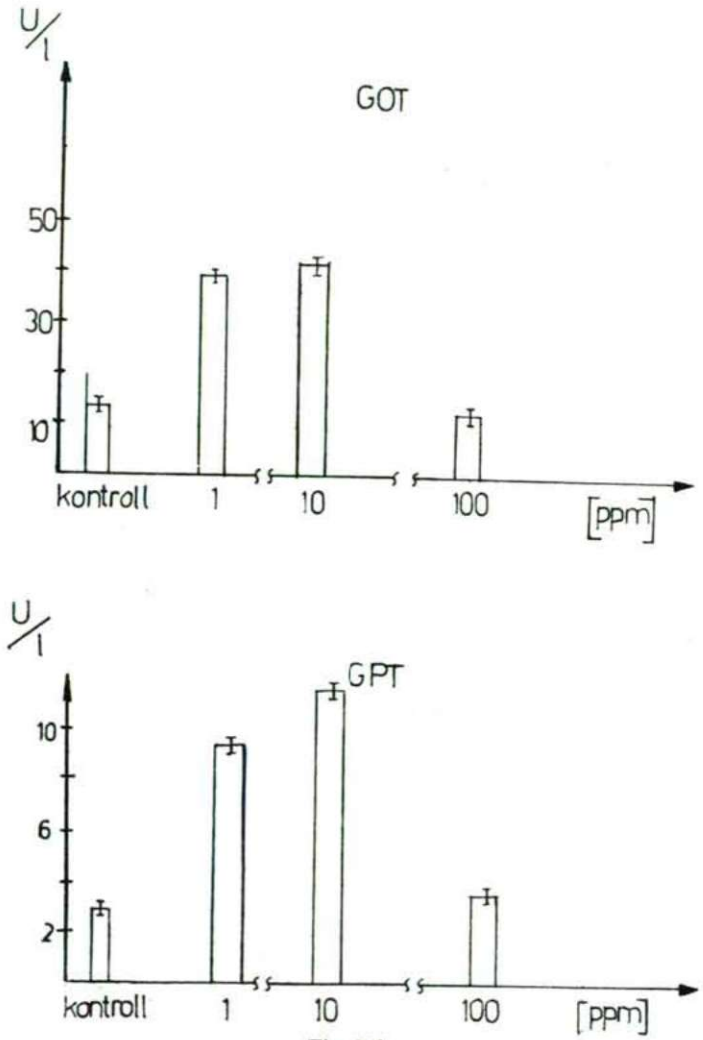


Fig. 2. b

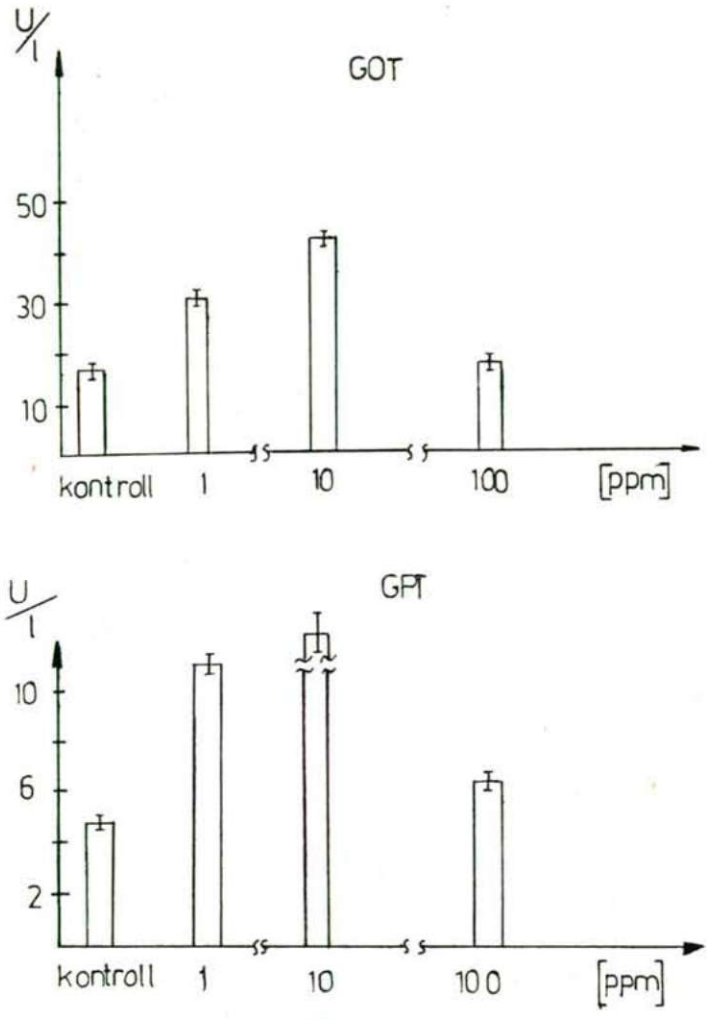
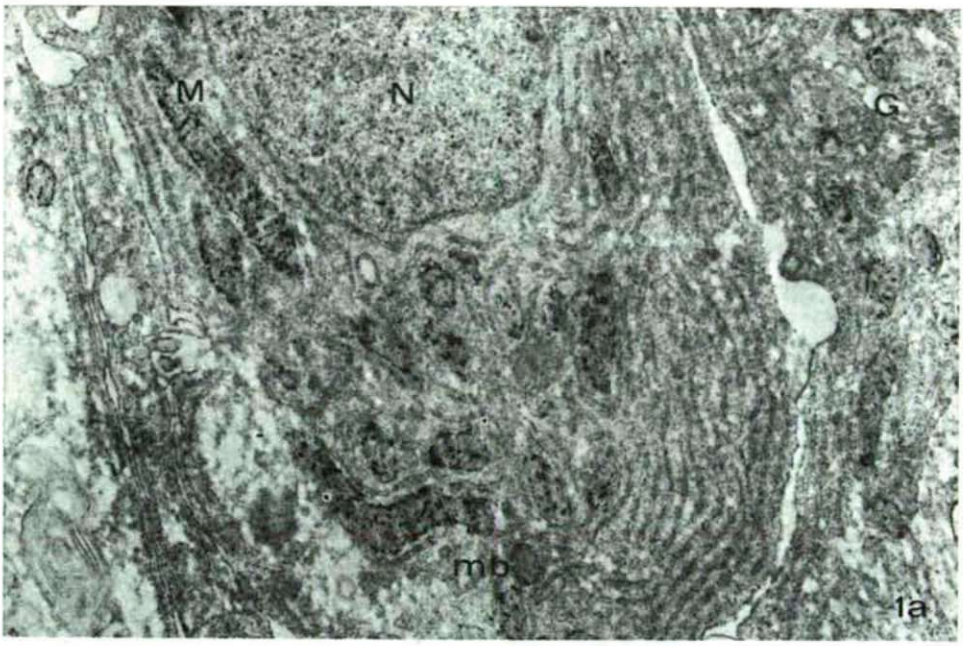


Fig. 2. c

Fig. 2a., b., c. The effect of 1, 10 and 100 ppm paraquat on the serum GOT and GPT activity of carp, (a), silver carp (b) and wells (c). Water temperature 20±1 °C. The given values are the average of 3—8 fishes (±S.D.) expressed in percent of the controls. Exposition time 2 hours, except at 100 ppm paraquat, where 10—15 min.

is depending on the species and on the different organs. These are supported by the findings of other authors (APPOLONIA and ANDERSON, 1980; KRISTOFFERSON et al., 1974).

Paraquat caused very serious tissue damage in each investigated fishes, but the degree of it was depending on the species. The main target of paraquat is presumably the gills-membrane, with disturbing effect on oxidative biochemical processes depending on the specific O_2 demand of the fish species.



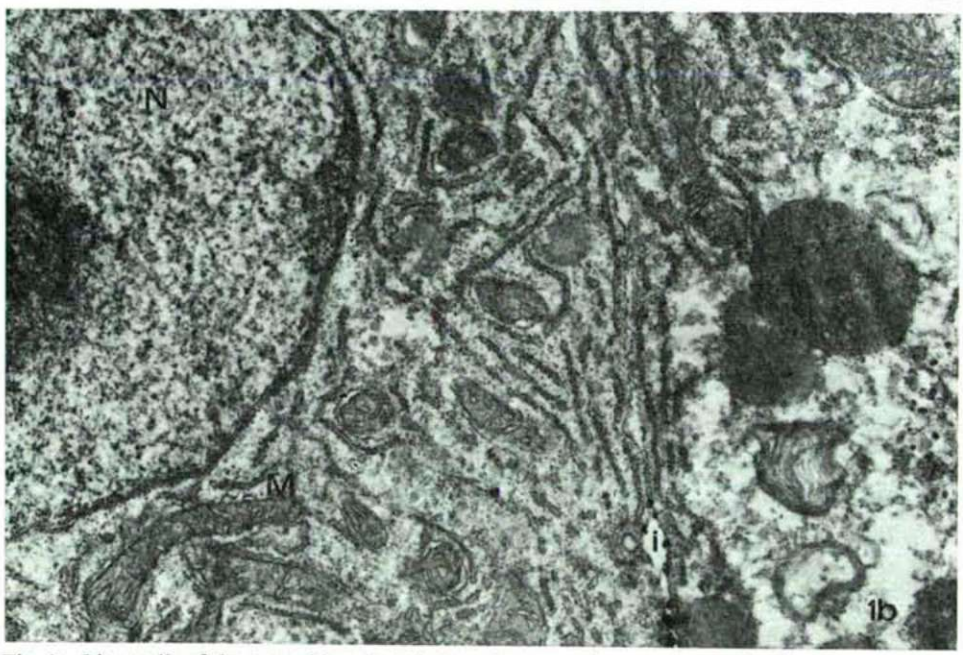


Fig. 1a. Liver cells of the carp. Abundant electron dense reaction product indicating the presence o enzyme — glutamate oxalacetate transaminase — can be seen in mitochondria (M) and multivesicular bodies (mb). Note fine granulted aspecific deposits also in the nucleus (N). G=Golgi apparatus. X 18.000.

Fig. 1b. Substrate free control. Note the lack of the reaction product in mitochondria (M) and other cell organelles in the liver cell of the carp. Rough granules in the interstitium (i) are aspecific accumulations of the lead. N=Nucleus. X 22.000.

On the basis of our cytochemical experiments, it can be established that the method described for demonstration of transaminase in mammalian species (LEE, 1973) is also applicable in the carp liver without any modification. The electron dense lead deposits — indicating the presence of the enzyme, glutamate oxalacetate transaminase — were accumulated in the mitochondria and multivesicular bodies (Fig. la). Other cell organelles, as for example Golgi apparatus were free from the reaction product but in the nucleus small aspecific granules were usually seen. Such kind of aspecific led accumulation used to be common also in other cytochemical procedures where lead ions were applied as capture agent (GÖMÖRI, 1950; NOVIKOFF, 1951). As regard the control tissues (Fig. 1b), both mitochondria and other cell organelles were free from reaction product, however, discontinuous granular deposits may occur in the intercellular spaces of liver cells as well as in the bile canaliculi.

Although LEE (1973) has been described the presence of transaminase in the cisternae of nuclear envelope in the rat liver, we were not able to demonstrate it in the case of liver cells of the carp.

References

D'APOLLONIA, S. and ANDERSON, P. D. (1980): Optimal assay conditions for serum and liver glutamate oxaloacetate transaminase, glutamate pyruvate transaminase, and sorbitol dehydrogenase from the rainbow trout, Salmo gairdneri. — Can. J. Fish. Aquat. Sci. *37*, 163—169.

BLOCK, E. R. (1979): Potentiation of acute paraquat toxicity by vitamin E defficiency. Lung *156*, 195—203.

CLARK, D. G., MC ELLIOTT, T. P. and BURST, E. W. (1966): The toxicity of paraquat. — Brit. J. Industr. Ned. *23*, 126—132.

FISHER, M. K., HUMPHERIS, M. and BAILS, R. (1971): Paraquat poisoning. Recovery from renal and pulmonary damage. — Ann. Int. Med. *75*, 731—736.

KRISTOFFERSSON, R., BROBERG, S., OIKARI, A. and PEKKARINEN, M. (1974): Effect of a sublethal concentration of phenol on some blood plasma enzyme activities in the pike (*Esox lucius* L.) in brackish water. — Ann. Zool. Fennici, 11, 220—223.

KARNOVSKY, M. J. (1965): A formaldehyde-glutaraldehyde fixative of high osmolarity for use in electron microscopy. — J. Cell Biol. *29*, 137 A.

GÖMÖRI, G. (1950): Sources of error in enzymatic histohemistry. — J. Lab. Clin. Med. *35*, 803.

LEE, S. H. (1973): Glutamate oxalacetate transaminase. In: Electron microcopy of enzymes. Principles and methods. Vol. I. — Ed. M. A. Hayat. VNR. N. Y. pp. 116—130.

NOVIKOFF, A. B. (1951): The validity of histochemical phosphatase on the intracellular level. — Science *113*, 320.

SPURR, A. R. (1969): A low viscosity epoxy resin embedding medium for electron microscopy. — J. Ultrastruct Res. *26*, 31—41.

STANCLIFFE, T. C. and PIRIE (1971): The production of superoxide radicals in the reactions of the herbicide diquat. — FEBS Lett. *17*, 297—299.

Address of the authors:
Dr. J. NEMCSÓK
Prof. Dr. L. BOROSS
B. ASZTALOS
L. ORBÁN
Department of Biochemistry
A. J. University, H-6701 Szeged,
P. O. Box 428. Hungary.
Dr. I. BENEDECZKY
Biological Research Institute
of Hungarian Academy of Sciences,
Tihany, Hungary.

Acta Biologica Szeged. 27 (1—4), pp. 17—23 (1981)

STUDY OF HOST-PARASITE INTERACTION IN TOMATO PLANTS*

B. MATKOVICS, L. SZABÓ and SZ. I. VARGA

(Received July 22, 1980)

Abstract

A quantitative comparative study was made of the peroxide metabolism enzyme (SOD, peroxidase and catalase), protein and ascorbic acid contents of homogenates of the roots, stem and lraves of 6 well-defined tomato varieties differing in sensitivity to tobacco mosaic virus (TMV), 15, 30and 50 days after TMV infection and in non-infected plants of the same ages. It was found that the virus infection and the development of the host-virus interaction leaves its impression on the plant metabolism even if the plant exhibits no external sign of the TMV infection.

Introduction

We earlier dealt with the quantitative changes in three plant (or animal) peroxide metabolism enzymes, namely superoxide dismutase (SOD; EC 1.15.1.1), peroxidase (P-ase; EC 1.11.1.7) and catalase (C-ase; EC 1.11.1.1.6), in plant seeds and during development of the bean plant (DO QUY HAI et al., 1975; KOVÁCS et al., 1975). These three enzymes are involved in the generation and decomposition of H_2O_2 (MATKOVICS, 1977).

The aim of the present work was to seek a correlation in the quantitative changes of the peroxide metabolism enzymes (PME) in normal and TMV-infected individuals of 6 well-defined tomato varieties of various ages. Simultaneous protein and ascorbic acid (AA) measurements were also made.

Materials and Methods

The tomato plants were obtained from the Vegetable Production Research Institute in Kecskemét. Money maker (MM) K 363 early and S.A.D. (Subarctic delight) late TMV-sensitive, -Tml homozygote, -Tml/+ heterozygote TMV-tolerant and -$Tm2^2$ TMV-resistant, varieties were examined. The plants were grown in air-controlled and artificially-illuminated green-houses, and were pricked out on the 12th day. Infection with a concentrate of TMV strain O was performed on the 14th day, by means of carborundum rubbing with a spatula (MÉSZÖLY et al., 1963). Samples were taken on the 15th, 30th and 50th days after infection, i.e. when the plants were 29, 44 and 64 days old.

The plants were washed free of dust and soil with tap-water, dried between filter papers, and 1 g wet weight was taken separately from the root, the stem and the leaf. The sample was ground with a minimal amount of quartz sand, washed into a centrifuge tube with 0.01 M phosphate buffer of

* Part XIII/A. Properties of enzymes. Serial publication.

pH 7.0 in a ratio of 1:5, centrifuged, and the enzymatic activity and other quantitative determinations were carried out on the supernatant.

The dry matter contents of the samples were also determined, after the plant parts had been dried to weight constancy at 105 °C.

Protein was determined by the method of LOWRY et al. (1951) with the Folin reagent, and AA by a colorimetric method with dinitrophenylhydrazine (ROE et al., 1943).

P-ase activity was determined spectrophotometrically with the quaiacol method at 470 mn (COLOWICK et al., 1955), and C-ase activity at 240 nm via the H_2O_2 decrease (BEERS et al., 1952). The C-ase activities were expressed in Bergmeyer units (BU). SOD was calculated via its inhibition of the autoxidation of epinephrine to adrenochrome in alkaline medium (MISRA et al., 1972; SIMON et al., 1974; MATKOVICS et al., 1977).

Enzyme activities were calculated with a PL/1 programme on an R 40 computer (Marburg, GDR). The errors in the enzyme activity determinations were ±5—10% (MATKOVICS et al., 1977), and in the protein and AA determinations were ±1—2%. Every result was the mean of at least 10 parallel measurements.

Spektromom 360 ans 201 spectrophotometers (MOM, Budapest) were emploed. The various chemicals used were products of Merck (Darmstadt, FGR), Boehringer (Mannheim, FGR) and Reanal (Budapest, Hungary), of the highest purity.

Results and discussion

The results are presented in 7 Figures and 3 Tables, arranged in chronological sequence. In the Figures the empty columns denote the data for the normal plants, and the shaded columns those for the virus-infected ones. Columns 1, 2 and 3 refer to the root, stem and leaf, respectively. The SOD activities in the 29-day-old plants were so low that it was not considered wortwhile to include them in the comparison.

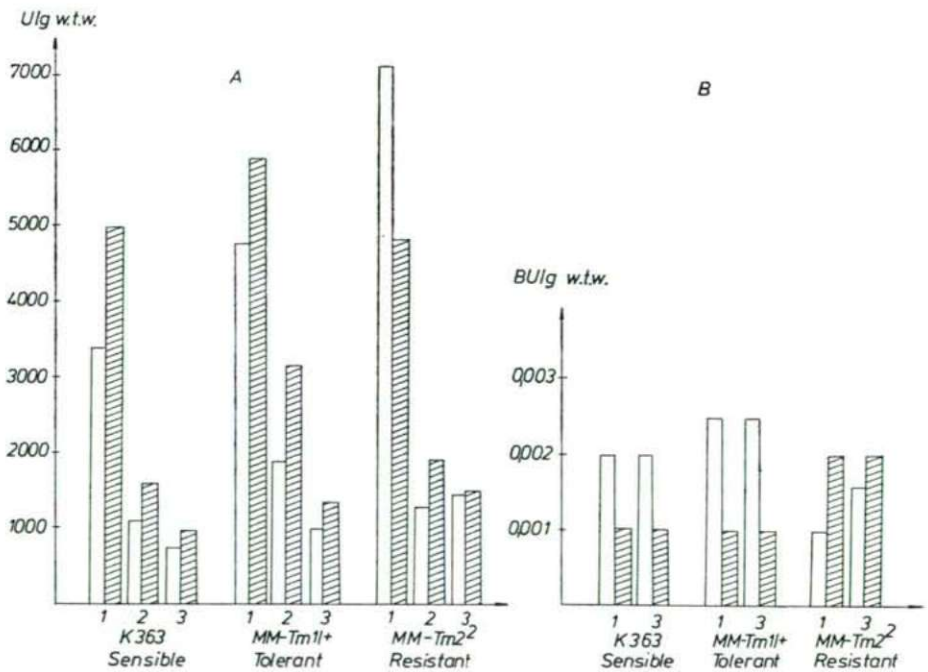


Fig. 1. P-ase (A) and C-ase (B) activities of 29 day old control and virus-infected tomato plants, measured in homogenate supernatants.

Figure 1 shows that in the TMV-sensitive and tolerant varieties the P-ase activities rise as a result of TMV infection. The changes in the root are very striking. In contrast, in the resistant variety the P-sae activity in the root decreases markedly. Hence, the changes in the P-ase, whether positive or negative, are characteristic of the infection.

C-ase can not be detected in the stems of the plants. Otherwise, it exhibits opposite tendencies to those observed for P-ase (cf. columns A and B in Fig. 1).

It may be seen in Fig. 2. that the protein determination method revealed somewhat higher values in the infected plants. The AA results for the infected plants were well in excess of those for the controls.

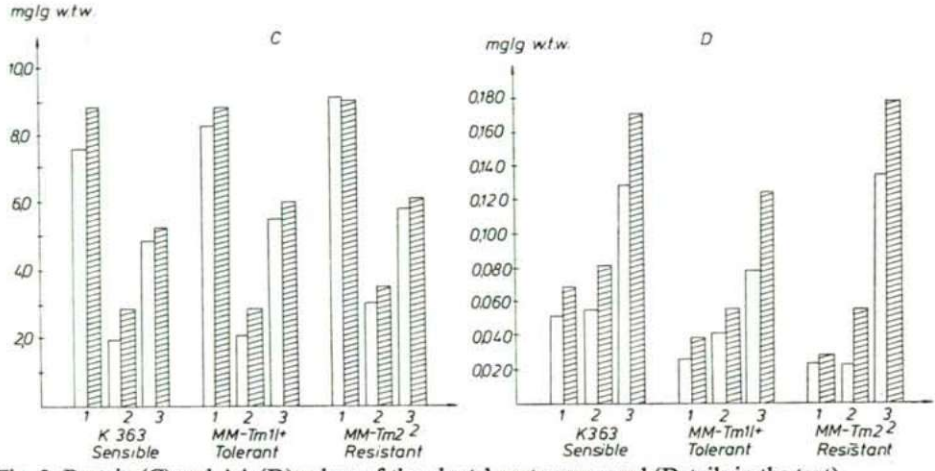


Fig. 2. Protein (C) and AA (D) values of the plants' parts compared (Details in the text).

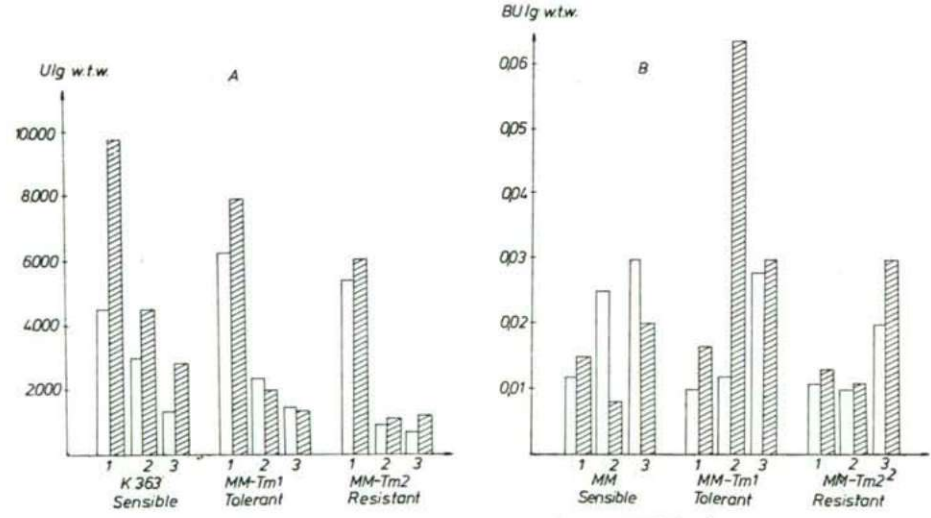


Fig. 3. P-ase (A), C-ase (B) activities compared 30 days after TMV infaction.

Figure 3 indicates that the P-ase values attain their maxima in the 44-day-old plants, but the differences between the controls and the infected plants are also maximum here. At this stage C-ase activity can be detected in all the plant parts, and increases considerably. With the exception of the stem and leaf homogenate supernatants for the sentivie MM variety, the tendencies are the same as for P-ase, i.e. the controls exhibit higher values.

Fiaure 4 shows that at this time the protein values (C) are lower and the AA results (D) higher for the infected plants than for the controls.

50 days after the virus infection, the P-ase (A) and C-ase (B) activities (Fig. 5)

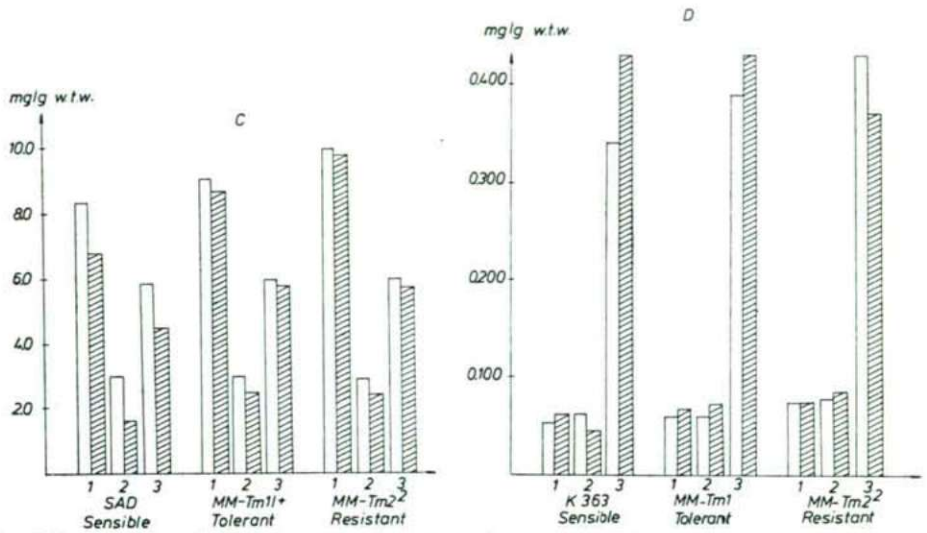


Fig. 4. Protein (C) and AA (D) measured 30 days after TMV infection (see the text).

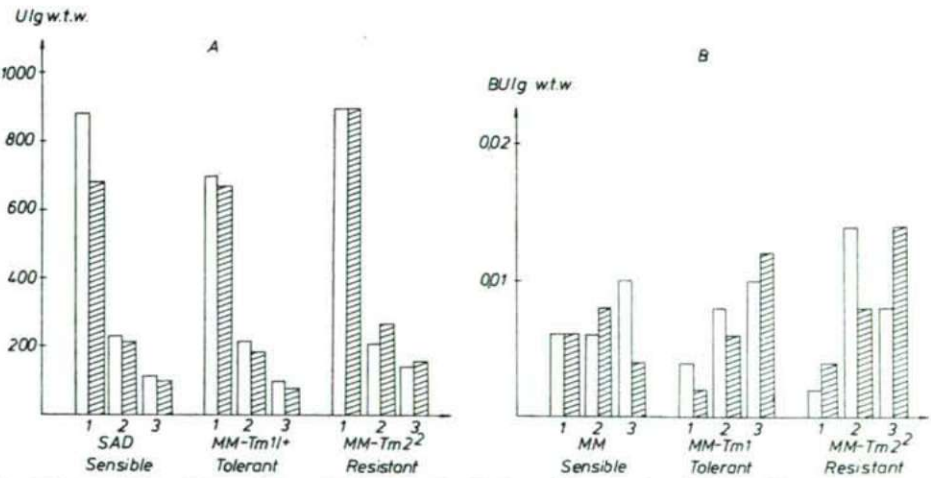


Fig. 5. P-ase (A) and C-ase (B) activities into the 64-days old control and infected tomatoes.

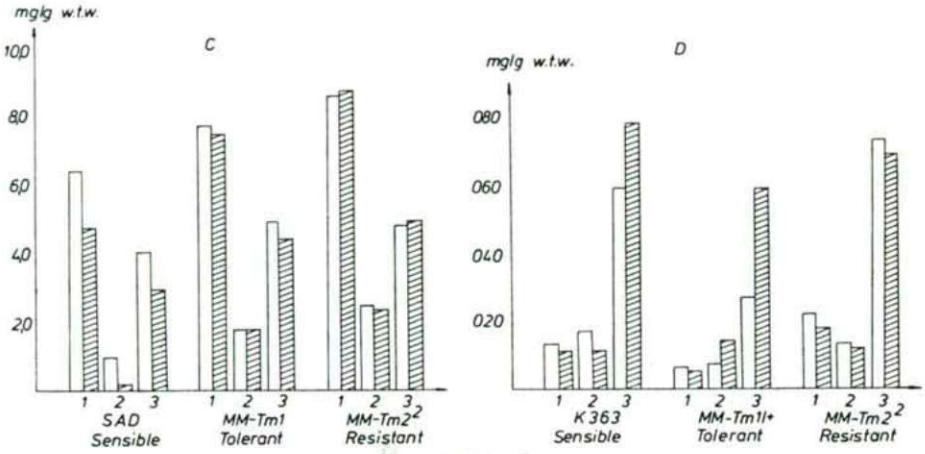


Fig. 6. 64 days old tomatoes protein (C) and AA (D) values.

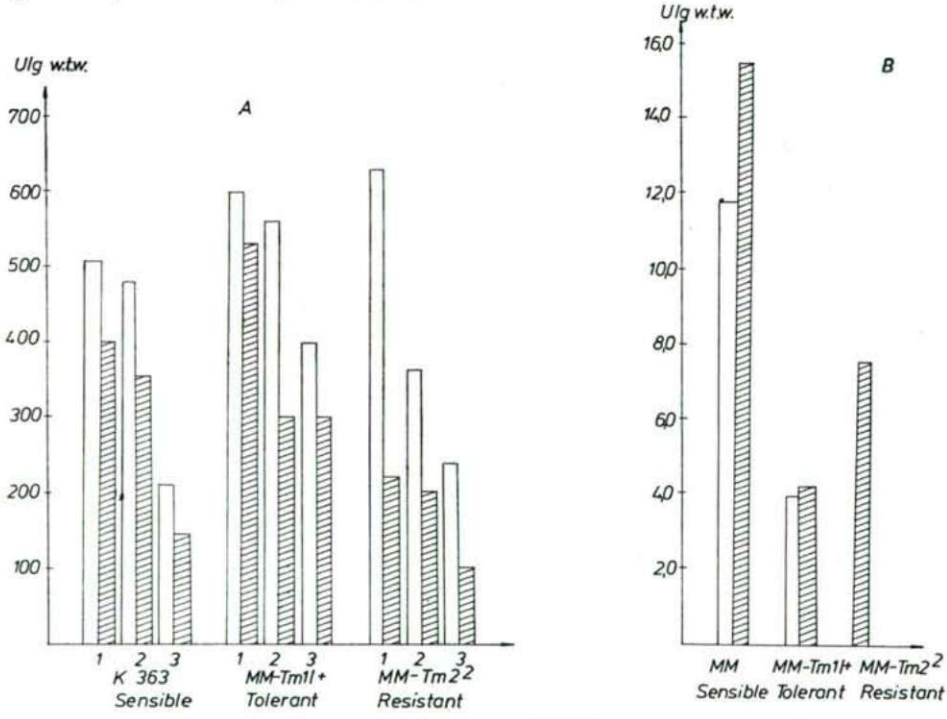


Fig. 7. SOD activities after 30 (A) and 45 (B) days after TMV infection (see the text).

and the protein (C) and AA (D) values (Fig. 6) are still reminiscent of the TMV infection from a metabolic aspect. Mainly the AA data still reveal large differences in the leaves of the sensitive and the tolerant plants.

Figure 7 compares the SOD activities in the various plant parts after 30 and 50 days of infection. In the latter case, only the stem data are of interest. After 30 days, the SOD activities are lower in all parts of the infected plants than in the controls, but after 50 days the stem of the infected plants yields a higher activity.

The measurements clearly demonstrate that, for all of the mechanisms examined, the tomato plant varieties "remember" the TMV infection even after their survival.

Much attention has earlier been paid (FARKAS et al., 1958, 1960; HALLIWELL, 1974) to the biochemical mechanism of the host-parasite interaction in plants. We wished to supplement the many previous part-data with a study of definite tomato varieties infected with TMV and kept under constant conditions. Our data tend to support the mechanism given by HALLIWELL (1974). This considers the primary characteristic of the parasite effect in the host-parasite interaction to be the accumulation of H_2O_2 and radicals formed from oxygen, and our enzyme examinations appear to support this (MATKOVICS et al., 1978).

The authors are grateful to Dr. JÓZSEF FARKAS of the Vegetable Production Research Institute, Kecskemét, for the plant material.

References

BEERS, R. F. JR. and SIZER, I. W. (1952): A spectrohphotometric method for measuring the breakdown of H_2O_2 by catalase. — J. biol. Chem. 195, 133—140.

DO QUY HAI, KOVÁCS, K., MATKOVICS, I. and MATKOVICS, B. (1975): Peroxidase and superoxid dismutase contents of plant seeds. — Biochem. Physiol. Pflanzen *167*, 357—359.

FARKAS, G. L. and KIRÁLY, Z. (1958): Enzymological aspects of plant diseases I. Oxidative enzyme. — Phytopath. Ztschr. *31*, 251—272.

FARKAS, G. L., KIRÁLY, Z. and SOLYMOSY, F. (1960): Role of oxidative metabolism in the localization of plant viruses. — Virology 408—421.

HALLIWELL, B. (1974): Superoxide dismutase, catalase and glutathione peroxidase: Solutions to the problems of living with oxygen. — New Phytol. *73*, 1075—1086.

KOVÁCS, K., SZŐNYI, D. G. and MATKOVICS, B. (1975): Purification and properties of human placental superoxide dismutase, and total peroxidase activities in normal and pathological cases. — Acta Biol. Szeged. *21*, 99—111.

LOWRY, O. H., ROSENBROUGH, N. J., LEWIS FARR, A. and RANDALL, J. (1951): Protein measurement with the Folin phenol reagent. — J. biol. Chem. *193*, 265—275.

MATKOVICS, B. (1977): The radicals of molecular oxygen and enzymatic cell defense against some of them. — Acta Univ. Lodziensis *16*, 103—145.

MATKOVICS, B., NOVÁK, R., HOANG DUC HAHN, SZABÓ, L., VARGA, SZ. I. and ZALESNA, G. (1977): A comparative study of some more important experimental animal peroxide metabolism enzymes. — Comp. Biochem. Physiol. *56*B, 31—34.

MATKOVICS, B., NOVÁK, R., SZABÓ, L., VARGA, SZ. I. and FARKAS, J. (1978): Enzymatic and metabolic changes of tomato plants after TMV infection. — Biochem. Physiol. Pflanzen *172*, 315—318.

MÉSZÖLY GY. és VIDÉKI L. (1963): Megfigyelések a paradicsom rezisztencia kialakításával kapcsolatban (Beiträge zur Tomatenresistenzzüchtung). — Duna—Tiszaközi Mezőgazd. Int. Évk. 17—37 (in Hungarian).

Methods in Enzymology, (Edited by: COLOWICK, S. P. and KAPLAN, N. O.) (1955) Academic Press, New York 764—.

MSRA, H. P. and FRIDOVICH, I. (1972): The role of superoxide anion in the autoxidation of epinephrine and a simple assay of SOD. — J. Biol. Chem. *247*, 3170—3175.

ROE, J. H. and KOESTHER, C. A. (1943): Determination of ascorbic acid. — J. Biol. Chem. *147*, 399—407.

SIMON, L. M., FÁTRAY, ZS., JÓNÁS, D. E. and MATKOVICS, B. (1974): Study of peroxide metabolism enzymes during the development of Phaseolus vulgaris. — Biochem. Physiol. Pflanzen *166*, 387—392.

Address of the authors:
Dr. B. MATKOVICS
Mr. L. SZABÓ
Dr. Sz. I. VARGA
Biological Isotope Laboratory
A. J. University, H-6701 Szeged,
P. O. Box 539. Hungary

Acta Biologica Szeged. 27 (1—4), pp. 25—31 (1981)

SOME DATA ON THE SUPEROXIDE DISMUTASE AND PEROXIDASE CONTENTS OF FRUITS, SEEDS AND DIFFERENT PARTS OF PLANTS*

B. MATKOVICS, SZ. I. VARGA and ILONA MATKOVICS

Biological Isotope Laboratory, Attila József University, Szeged
(Received July 22, 1980)

Abstract

As a supplement to earlier work, in the present paper we deal with a comparison of the superoxide dismutase (SOD) and peroxidase (P-ase) contents of various commercial fruits and vegetables, and also with the values of these enzymes in certain seeds, and with their comparison in plant parts of different ages, and particularly the leaves.

Introduction

In previous work we studied and compared the peroxide metabolism enzymes in *Phaseolus bulgaris* plant parts of various ages, viz. the contents of superoxide dismutase (SOD; EC 1.15.1.), peroxidase (P-ase; EC 1.11.1.7) and catalase (C-ase; EC 1.11.1.16) (SIMON et al., 1974).

We subsequently dealt in detail with the comparison of the seeds' peroxidase (SP-ase) and SOD contents of some mono- and dicotyledonous plants (DO QUY HAI et al., 1975).

The present paper is a supplement to these eralier investigations.

Materials and Methods

Preparation of plant seeds and plant parts for examination of the enzymes:

The seeds were prepared as described previously (DO QUY HAI et al., 1975).

The plant parts were first separated, cuted into pieces with scissors, weighed and ground with quartz sand. If P-ase was being determined, moistening was performed with 10 mmol/1 phosphate buffer pH 7.0. The homogenate was filtered through gauze, and an aliquot of the solution was taken for determination of the P-ase activity after requisite dilution with the above buffer. P-ase activity was determined by the quaiacol method (COLOWICK et al., 1955). (The basic principles described for the P-ase calculations were employed in the calculations given in the graph.) The results were transformed to specific activity units, and are given as follows: for the seeds: in enzyme units/g dry seed (d.s.w.) weight; and for the plant parts, vegetables, fruits and leaves: in enzyme units/g wet weight (w.w.).

The preparation of the seeds for the SOD measurement was as described previously (DO QUY HAI et al., 1975.); after the above weighing, pretreatment and grinding, the other parts were generally

* Part VI/A. Properties of enzymes. Serial publication.

moistened with 0.1 M K_2HPO_4 solution. Pressing through gauze was followed by addition of an ethanol-chloroform mixture (0.25:0.15) to the filtrate, 0.35 ml of this organic solvent mixture being taken for each 1 ml of the K_2HPO_4 extract. Shaking with the solvent was succeeded by centrifugation at 5000 rpm. An aliquot (0.005—0.1 ml) of the SOD-enriched solvent extract was used for determination of the enzyme (MISRA et al., 1972).

SOD activity was investigated via the inhibition of the spontaneous transformation adrenaline — adrenochrome in alkaline medium, in which the O_2^- anion takes part (MISRA et al., 1972).

The plant materials were collected, and the determinations were performed, in March and April in 1974.

Those plants the roots, stem and leaves of which were analyzed, were planted out in pots, and were grown in greenhouses.

The plants examined were: *Allium cepa* L. (onion), *Allium sativum* L. (garlic), *Capsicum annuum* L. var *abbreviatum Cecei* (pepper), *Capsicum annuum* L. var. *Lycopersiciforme* (pepper), *Citrus aurantiacum* L. ssp. *sinesis* PALL (orange), *Solanum tuberosum* L. (potato), *Raphanus sativus* L. (radish), *Citrus medica* L. (lemon), *Matthiola bicornis* (S. SM.) DC. *Sorgum vulgare* L. hybrid (sorghum), Triticale, *Ipomoea purpurea* (L.) LAM. *Lactuca sativa* L. (lettuce), *Glycine soia* L. (soya bean), *Phaseolus coccineus* L. (runner bean), *Linum usitatissimum* L. (flax), *Daucus carota* L. (carrot), *Aster novibelgii* L. (aster), *Cannabis sativa* L. (hemp), *Petroselium hortense* L. (parsley), *Chenopodium amaranti-color, Chenopodium quinoa, Ocinum basilicum* L., *Nicotiana tabacum* L. var. *glutinosa, Nicotiana tabacum* L. var. *samsum, Nicotiana tabacum* L. var. *Bell, Spinacia oleracea* L. (spinach), *Brassica oleracea* L. var. *capitata* L. forma *alba* (white cabbage), *Brassica oleracea* L. var. forma *rubra* (red cabbage).

Spektromom 360 photometer (MOM, Budapest, Hungary) was used for the spectrophotometric measurements at 470 and 480 nm.

The chemicals and solvents employed were commercial products of Reanal (Budapest, Hungary)

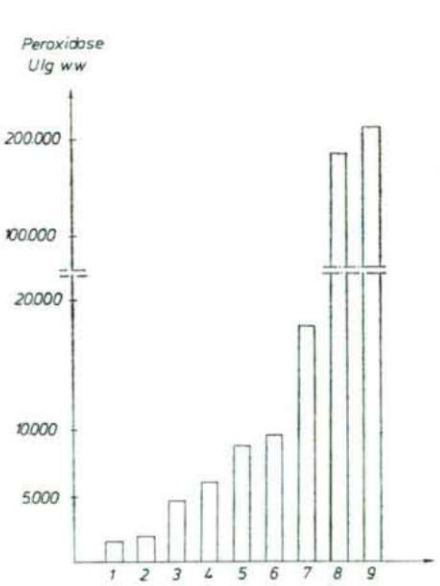


Fig. 1

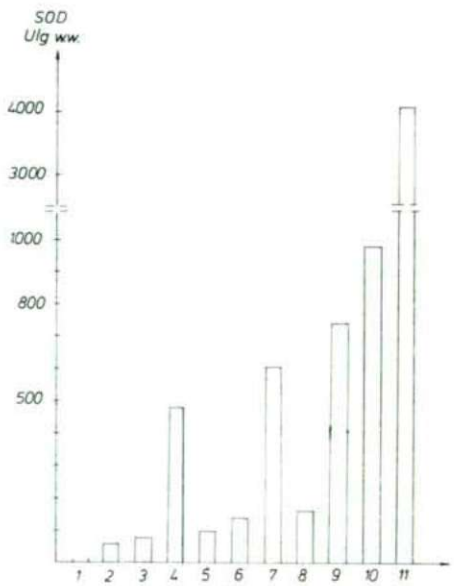


Fig. 2

Fig. 1. P-ase contents of various vegetables and lemon peel, in U/g w.w. Sequence of columns: 1. onion; 2. garlic; 3. *Capsicum annuum* var. *abbreviatum* Cecei; pepper but var. *lycopersiciforme;* 5. orange peel; 6. potato tissue; 7. potato peel; radish; 9. lemon peel.

Fig. 2. SOD contents of various vegetables and friuts, in U/g w.w. Sequence of columns: 1. potato peel; 2. potato tissue; 3. orange peel; 4. orange tissue; 5. onion; 6. lemon peel; 7. lemon tissue; 8. garlic; 9. Cecei's pepper; 10. radish; 11. tomatoform pepper.

Results and discussion

Presenting the results in the sequence of the graphs, we deal first with the P-ase, and then with the SOD values. Figure 1 shows the P-ase contents of some vegetables and orange and lemon peel. It can be seen from the Figure that of the vegetables listed, the radish has the highest P-ase content, but this is exceeded by that of lemon peel.

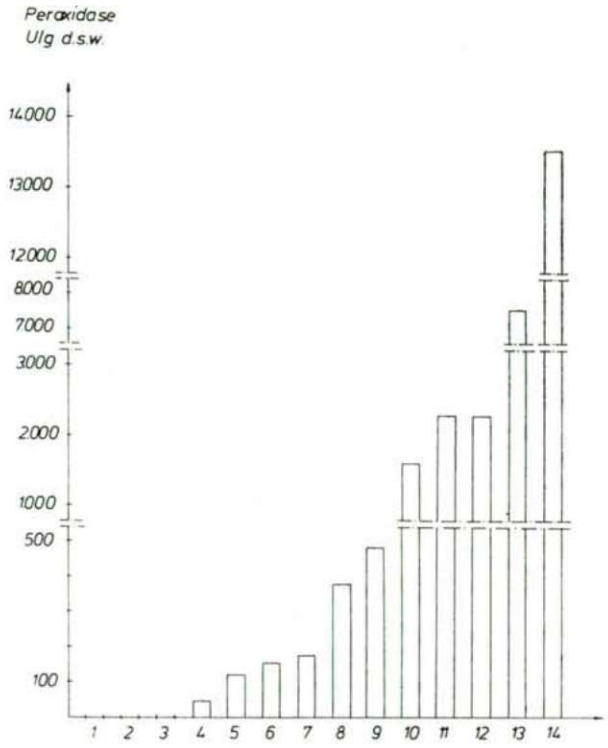


Fig. 3. Seeds examined for SP-ase content: 1. flax; 2. carrot; 3. *Matthiola bicornis;* 4. cabbage; 5. aster; 6. sorghum (hybrid); 7. radish; 8. hemp; 9. Triticale; 10. persley; 11. Ipomea purpurea; 12. lettuce; 13. soya bean; 14. runner bean.

Substantially lower activity values are found for the SOD contents of these vegetables and fruits. Here the activity sequence too is different (see Fig. 2). The high SOD values of the early radish and the *Capsicum annuum* L. var. *abbreviatum* Cecei (Cecei's pepper) must be singled out. It is intersting that potato peel contains no SOD at all, and the SOD content of the tissue of potatoes is very low.

Figure 3 shows the seed peroxidase (SP-ase) values. These measurements supplement our earlier data, in the same way as Figure 4 does for the SOD values (Do Quy Hai et al., 1975). In both Figures the high SP-ase and SOD values of the soya

bean should be emphasized. It must be mentioned that the seeds in the first three columns of Figure 3 and 4 do not contain SP-ase and SOD. An example of this is the carrot seed. Of all the seeds examined to date that of the soya bean has the highest SOD content. On the basis of the SP-ase content the soya bean can be classified among the seeds with medium SP-ase content. In the present comparison its SP-ase content is exceeded by that of the runner bean.

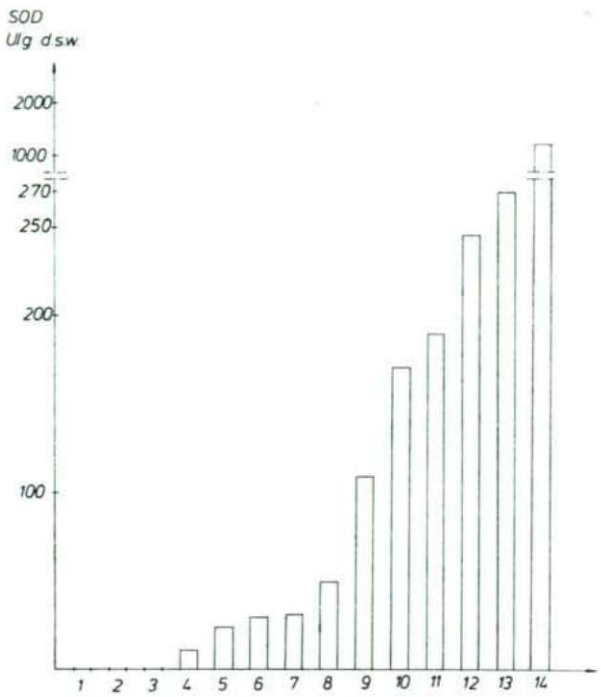


Fig. 4. Seeds examined for SOD content: 1. lettuce; 2. *Ipomoea purpurea;* 3. carrot; 4. sorghum (hybrid); 5. parsley; 6. hemp; 7. Triticale; 8. aster; 9. flax; 10. *Matthiola bicornis;* 11. runner bean; 12. radish; 13. cabbage; 14. soya bean.

Figure 5 shows the P-ase values of the parts of four plants grown in the greenhouse: The two varieties of *Chenopodium, Ocimum,* pepper and tobacco. Details on these same plants as regards SOD content are given in Figure 6. In general the P-ase values exhibit a variable distribution. On the other hand, the SOD values are the highest in the leaves in every case.

Figure 7 and 8 present the P-ase and SOD valwes of plant leaves and vegetables of various ages.

The high P-ase activity values of cabbage varieties in Figure 7 should be singled out, the highest value being that of red cabbage.

The SOD content too is the highest in the above plants (see Fig. 8).

The large number of comparisons relating to the two enzymes of the peroxide metabolism well support the role of the metabolite considered of importance in con-

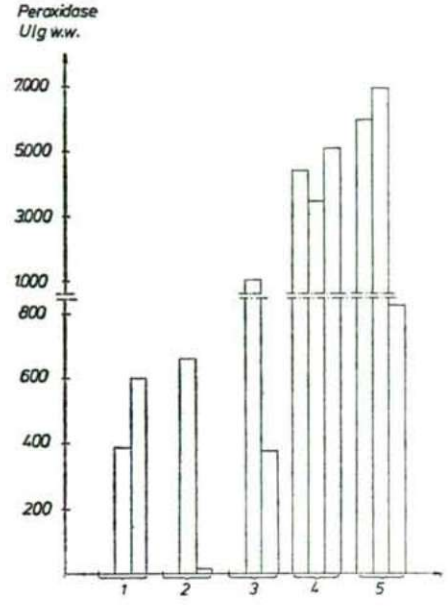


Fig. 5. Sequence of numbers relating to the P-ase activities of the plant parts: 1. *Chemopodium amaranticolor;* 2. *Ocimum basilicum;* 3. *Chenopodium quinoa;* 4. pepper; 5. *Nicotiana tabacum* var. *glutinosa.* (As regards the relevant columns, in all cases the first refers to the root, the second to the stem, and the third to the leaf.)

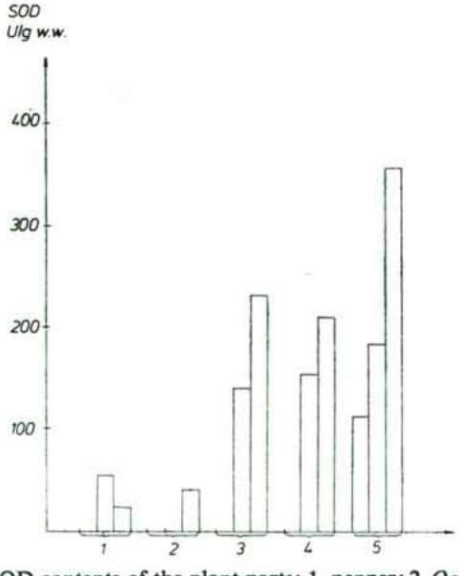


Fig. 6. Sequence for the SOD contents of the plant parts: 1. pepper; 2. *Ocimum basilicum;* 3. *Chenopodium quinoa;* 4. *Chenopodium amaranti-color;* 5. *Nicotiana tabacum* var. *glutinosa.* (The same refers to sequence of the columns as in Fig. 5.)

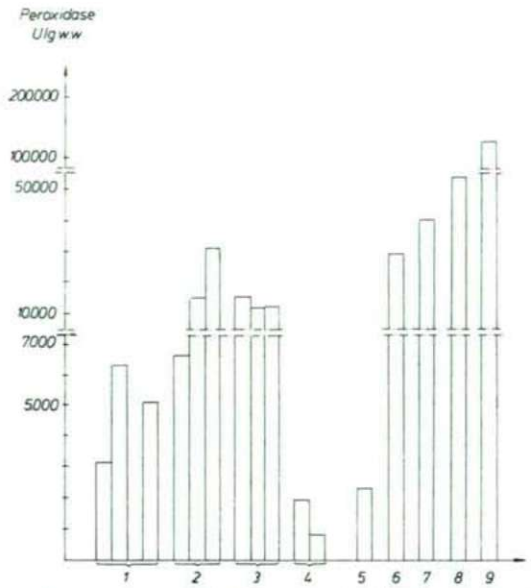


Fig. 7. P-ase of the leaves (in some cases of different ages) of various vegetables: 1. pepper (2-leaf, 30, 50 and 80 days old); 2. 3 types of 30 days old tobacco (*Nicotiana tabacum* var. *glutinosa*, var. *samsum* and var. *Bell*); 3. the same 3 types of 80 days old tobacco; 4. *Chenopodium* (*Qunoa* and *amarati-color*); 5. lettuce; 6. spinach; 7. radish; 8. white cabbage; 9. red cabbage.

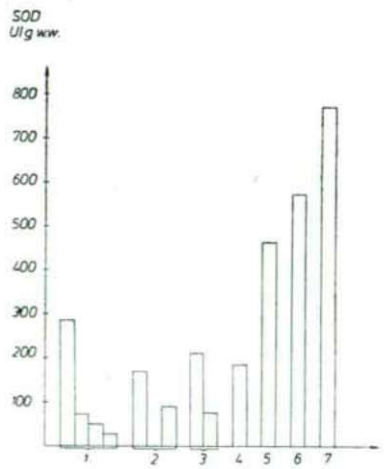


Fig. 8. SOD activities of vegetable leaves: 1. pepper (2-leaf), 30, 50 and 80 days old); 2. *Nicotiana tabacum* var. (as in Fig. 7.); 3. the 2 *Chenopodium* species; 4. spinach; 5. radish; 6. white cabbage; 7. red cabbage.

nection with the P-ase, and the role of the SOD in the protection against the O_2^- anion.

We carried out the examinations reported in the paper in 1975. Since then, only a two-part paper on this topic has been published (GIANNOPOLITIS et al., 1977 a, b).

Accordingly, the work appearing in this field is still in the descriptive stage.

References

COLOWICK, S. P. and KAPLAN, N. O. (1955): Methods in Enzymology, Vol. II. pp. 764. Academic Press, London

DO QUY HAI, KOVÁCS, K., MATKOVICS, I. and MATKOVICS, B. (1975): Properies of Enzymes, Part X. Peroxidase and Superoxide dismutase Contents of Plant Seeds. — Biochem. Physiol. Pflanzen *167*, 357—359.

GIANNOPOLITIS, C. N. and RIES S. K. (1977a): Superoxide dismutases. I. Occurence in higher plants. — Plant Physiol. *59*, 309—314.

GIANNOPOLITIS, C. N. and RIES S. K. (1977b): Superoxide dismutases. II. Purification and quantitative relationspip with water-soluble protein in seedlings. — Plant Physiol. *59*, 315—318.

MISRA, H. P. and FRIDOVICH, I. (1972): The role of superoxide anion in the autoxidation of epinephrine and a simple assay for superoxide dismutase. — J. Biol. Chem. *247*, 3170—3175.

SIMON, L. M., FÁTRAY, Zs., JÓNÁS, D. E. and MATKOVICS, B. (1974): Study of peroxide metabolism enzymes during the development of *Phaseolus vulgaris*. — Biochem. Physiol. Pflanzen *166*, 387—392.

Address of the authors:
Dr. B. MATKOVICS
Dr. SZ. I. VARGA, ILONA MATKOVICS
P. O. BOX 539.
H-6701 Szeged, Hungary

Acta Biologica Szeged. 27 (1—4), pp. 33—53 (1981)

CORRELATIONS BETWEEN VEGETATION AND HYDROECOLOGY IN THE SANDY GRASSLANDS OF KISKÚNSÁG NATIONAL PARK

GY. BODROGKÖZY and GYÖNGYI FARKAS

Botanical Department, Attila József University, Szeged
(Received September 22, 1980)

Summary

In 1978—1979 investigations were performed on vegetation and soil-ecology in Bugac puszta area of Kiskúnság National Park on the assotiations *Festucetum vaginatae danubiale* Soó 29, *Potentillo (arenariae)-Festucetum pseudovinae danubiale* Bodrk. 59, *Lolio-Potentilletum anserinae* (Rpcs 27) KNAPP 46, and *Molinio-Salicetum rosmarinifoliae* (MAGYAR 33) Soó 57. It was established that in each stands due to inland drainage and increased zoogenic effects species with a wider ecological adaptability became dominant forming subassociations with *Festuca pseudovina*. The expansion of meso-xerophyta was observed. Correlation was established in number and dominancy between species of the higher cenological units and those of different hydroecological groups. It was established that in the studied area the vegetation largely lost the typical species-combinations due to increasing anthropogenic and zoogenic effects. It would be desirable to inhibit further degradation.

Introduction

In January 1975 was established the second National Park of Hungary, the Kiskúnság National Park. Upon the managements request complex ecological investigations were commenced on the Bugac puszta area in cooperation with the Department of Botany and Department of Zoology of the Attila József University, Szeged. Authors' investigations were performed within this frame.

Materials and Methods

For synecological investigations of the characteristic sandy grassland between the Danube and Tisza in the range of Bócsa—Bugac offers an adequate study area in which the characteristic stands are situated nearby. Authors' aim was to establish the consequences of changes of ecological (including soil-ecological and biogeneous) factors and the mutual influences between the adjacent associations. During the vegetation periods of 1978 and 1979 phytocenological investigations were monthly performed with the aid of refined evaluation methods. In the summarized evaluation the averaged results of the spring, summer and fall aspects were used in respect of species number and dominancy values as well. The species of the different associations were distributed into hydroecological groups and subgroups as follows: helo-hygrophyta (hhg), hygrophyta (hg), meso-hygrophyta (mhg), mesophyta (m), xero-mesophyta (xm), meso-xerophyta (mx), asteno-xerophyta (ax), and steno-xerophyta (sx) (BODROGKÖZY, 1977).

For the investigation of the soil-ecological factors (supposed to be the decisive) soil profiles were exposed. If a soilgenetical stratification could be established sampling was performed according

to the layers. In the laboratory pH, $CaCO_3$ and organic matter determination as well as mechanical analysis were performed. The latter is an important factor in the nutrition and water supply. According to the methods of the Guide Book of Soil Investigation were performed the basic investigations. For the mechanical analysis partly sieves, parthly the lithium carbonate method, the A-hydrometer and as control the pipette method were used. The separation of the following fractions was reasonable:

0.4 mm	0.1—0.02 mm
0.2—0.4 mm sand	0.02 mm
0.1—0.2 mm	

In favour of lucidity, instead of tables, the data of soil investigations were presented in three-dimensional diagrams showing also the height of the vegetation.

The vegetation on the sand is decisively influenced by the humudity of the soil. In connection with this, investigations were performed in the fall of 1979 when precipitation was meagre. Using different methods different results may be obtained. From these usually only one is taken into consideration — which does not give always a real picture. Authors consider as successful the graphical evaluation of the soil humidity as per cent of of dry weight, as per cent of wet weight and as water volume in soil volume (l/dm³) (BODROGKÖZY, 1978).

In the hydroecological grouping of the species the following groups and subgroups were distinguished: helo-hygrophyta (hhg), hygrophyta (hg), meso-hygrophyta (mhg), mesophyta (m), xeo-mesophyta (xm), asteno-xerophyta (ax), and steno-xerophyta (sx). In the cenological tables these groups were used instead of the usual groups of cenosystematics (BODROGKÖZY, 1978). To make easier the surway a graphic method was used instead of tabulating numerical data.

General charachterisation of the area

The study area is situated in the middle of Praematricum, the third floristic part of the Great Hungarian Plain. The succession can be followed from *Festucetum vaginatae* on the sand hill ridges till the sandy forests (BODROGKÖZY, 1957). Formerely, large sand meadows and pastures occupied the area but from the last century the greater part was drawn into agronomical cultivation. Beautiful examples of the remains of the original forest-steppe are found in Csévharaszt, Pusztavacs and Bugac.

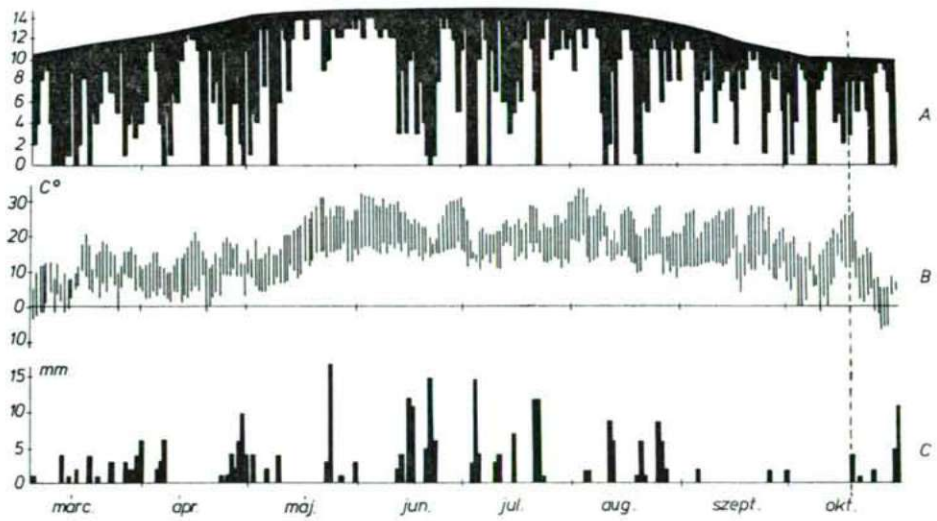


Fig. 1. Weather conditions during the vegetation period in the second year of investigations.

There are wellknown the phytocenological and production biological investigations of Simon and coworkers (SIMON and KOVÁCS-LÁNG, 1964; KOVÁCS-LÁNG and SZABÓ, 1971; VERSEGHY and KOVÁCS-LÁNG, 1971; SZABÓ, 1975).

From climatoloaical point of view it is characteristic of this area (which is one of the most sunlighted area of the country) that the yeraly mean of cloud covering is about 50 per cent; the number of sunny hours may surpass 2000. It is the hottest area of the country even in the vegetation period (Fig. 1). Composition of the vegetation is also influenced by the fact, that it is the area with short winters and long summers in Hungary.

Wind, an important factor in ecology, is also decisive in the formation of the surface. Direction of the stronger winds (8 m sec^{-1}) is in 20 per cent NW and in 19 per cent WNW. Accordingly are situated the sand hills and the hollows between them.

At the same time this area is the most arid part of the country: the yearly precipitation is 500—550 mm. From this, in the vegetation period (April—September) falls 300—350 mm. Drought occurring in summers, which may continue till the early fall too, is the consequence of unsettledness of weather.

On the area the base rock of the blown sand consists mostly of coarse quartz-sand containing less than 5 per cent particles below 0.2 mm. On the ridges the soil profiles are homogeneous, genetical layers can hardly be distinguished. All investigated profiles contain $CaCO_3$ in different quantities. This can have considerable physiological effects. According to KREYBIG the $CaCO_3$ content considerably influences the absorption capacity of the soil particles. In the case of high $CaCO_3$ content the soil can retain humudity in a degree that inhibits water uptake by plants. Different productivity of sandy soils is due to their different supply in organic matter and nutrients. Nutrient uptake is enhenced by physical characteristics of the soil. Their physico-chemical characterization is given by SZABÓ (1975).

In the evolution of the associations on the sands between the Danube and Tisza a correlation can be supposed with the water table in the soil. This is wellknown in connection with the forests. The connections with forestry were investigated by SZODFRIDT and FARANGÓ (1968). SZODFRIDT published data about infiltration of water, about the course of water moving in sandy soils (1971) and about the connections between natural plant associations and hydrology of these soils (1974). He also pointed out the importance of the evaluation of the water content in volume, weight in connection with water-economy of sandy soils.

Connections between hydroecology of vegetation and soil conditions

On the basis of the data averaged from two vegetation periods connections between the distribution of species' hydro-ecological groups and characters of the soils were established as follows:

Festucetum vaginatae danubiale (Rpcs. 23) Soó 29

This association occurs on the highest parts of the sand hill ridges of the study area. In consequence of the extreme ecological situation, the excessive pasturing and the drop of the water table after inland drainage resulted in a specific phytocenological and soil-ecological situation.

Soil-ecology. The soil profile of the blown sand is without expressed soil-genetical layers. Organic matter content in layer A (layer of the roots) is 1.4 per cent, higer than measured in other sites of the association, assuring a better nutrients supply. According to its $CaCO_3$ content and pH (6.4—6.7) it may be considered as an acidic blown sand (Fig. 2) reflected also in the spectrum of species. The fraction smaller than 0.1 mm is 6.37—7.95 per cent, so it may be considered as a little bit fixed type of blown sand (Fig. 2).

Humudity (measured in October 1979) as expressed in per cent of dry weight and per cent of wet weight showed nearly identical curves; not exceeding 5 per cent even in the zone of the roots.

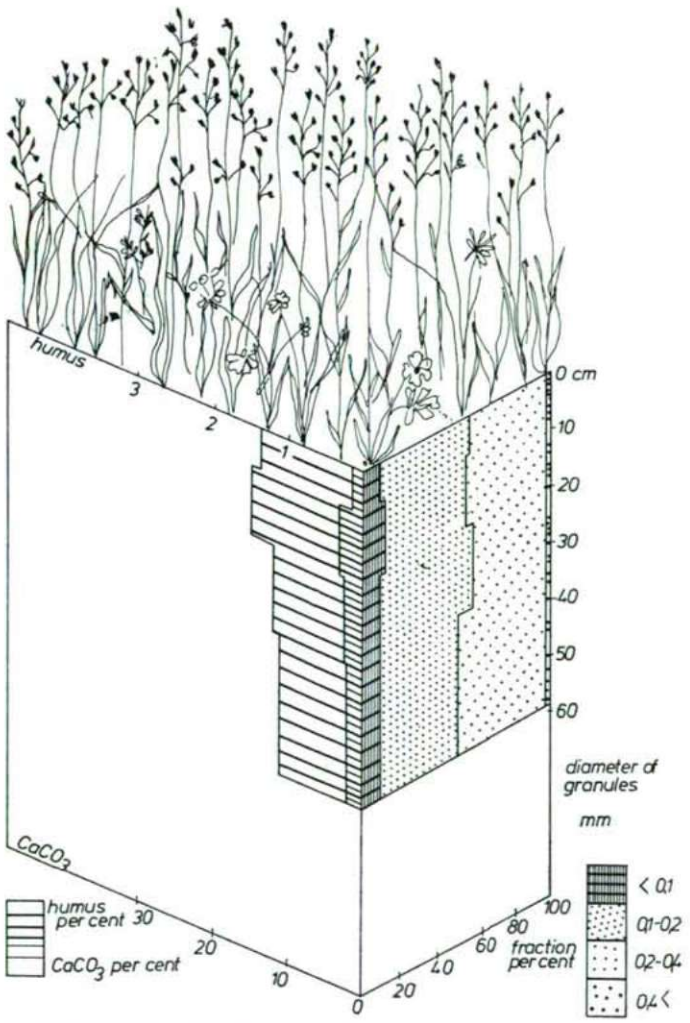


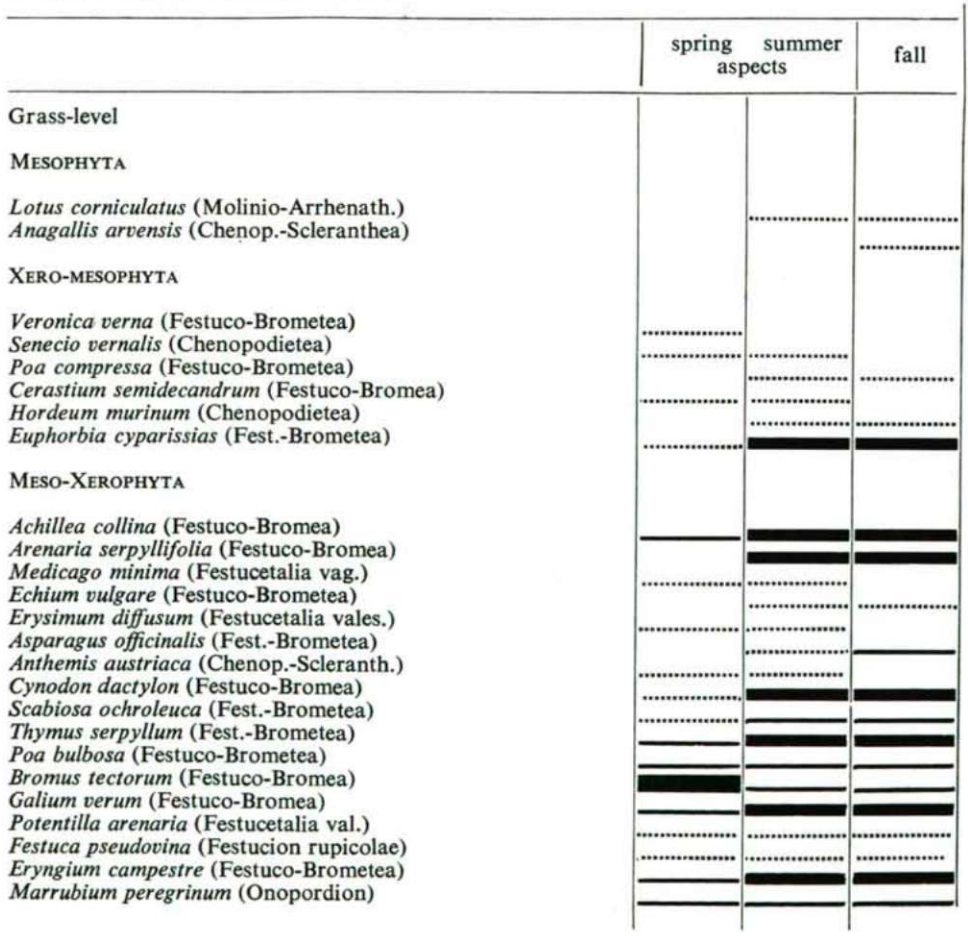
Fig. 2. Characters of soil profile of *Festucetum vaginatae*.

Analysing the species combination a connection can be established between pH, nutrients supply, hydrological characters and qualitative and quantitative occurrence of the different species groups. Occurrence of Trifolium arvense can be connected with low pH and low $CaCO_2$ content. The relatively favourable organic matter content reflects in the high number of species and high grade of covering.

Considering the distribution of the composing species into hydro-ecological groups, asteno-xerophyta and steno-xerophyta surpasse in number the xero-mesophyta and meso-xerophyta (Table 1); this can be connected with the favourable nutrient supply. Considering dominancy the picture is invers: the fourth of the meso-xerophyta occurs only by threads of remained only with a very low dominancy (Table 3).

A correlation was also established between the species components of the higher cenological units and the corresponding hydro-ecological groups and subgroups

Table 1. Festubetum vaginatae danubiale



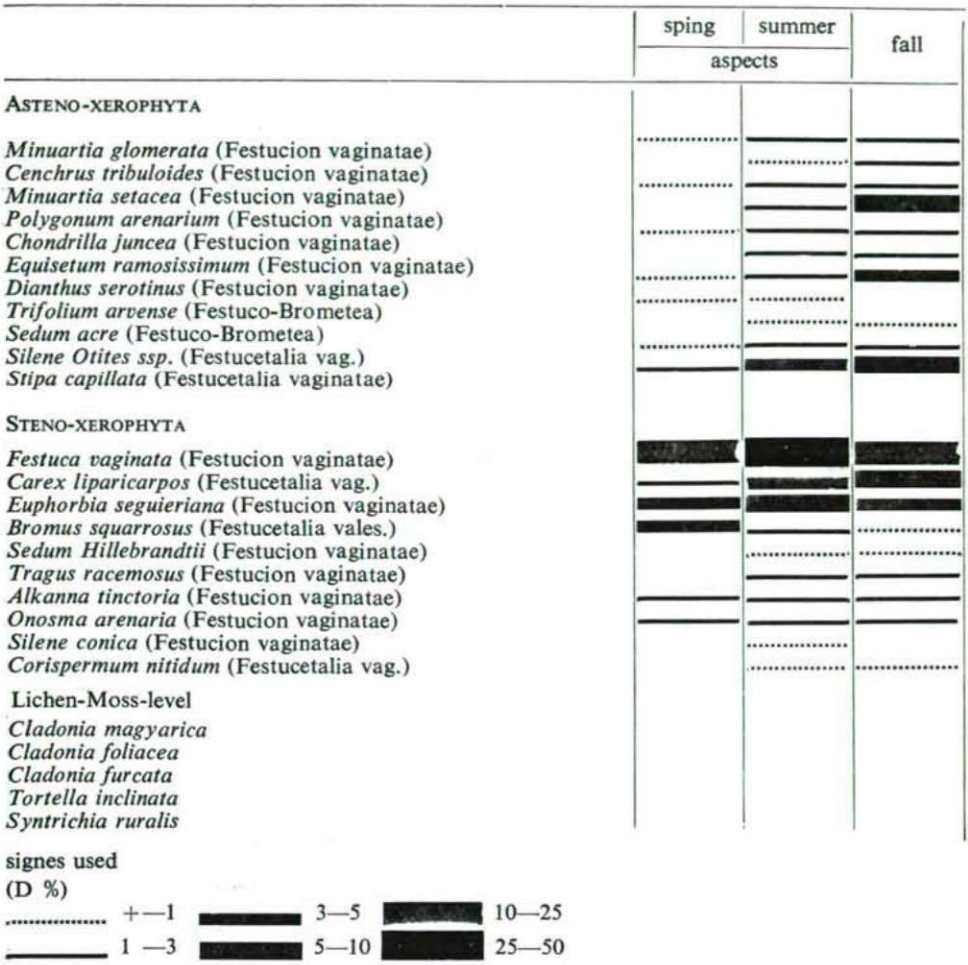


Table 2. Distribution according to number of species

number of species			per cent	number of species			per cent
Molinio-Arrhenatheretea	1	1	2.2	m	2	2	4
Festucetalia valesiacae	4			xm	6		
Festuco-Brometea	11	26	56.4	mx	17	23	50
Festuco-Bromea							
Onopordion. Chenopodietea	11						
Chenop.-Scleranthea							
Fesucion vaginatae	15	19	41.4	ax	11		
Festucetalia vaginatae	4			sx	10	21	46

Table 3. Distribution of the species of *Festucetum vaginatae* into cenosystematic and hydroecologic groups according to dominancy in the three aspects.

	spring	summer	fall		spring	summer	fall
					aspect		
Mol.-Arrhenatheretea	0.5	0.5		m	1.0	0.5	
Festucetalia valesiacae	4.0	8.5	2.0	xm	3.5	6.0	3.0
Festuco-Brometea Festuco-Bromea	14.0	21.5	25.0	mx	16.0	24.0	21.0
Chenopodietea Onopordion Chen.-Scleranthea	2.5	3.5	1.5				
Festucetalia vaginatae	9.5	11.5	12.0	ax	7.5	10.0	14.0
Festucion vaginatae	19.5	28.5	34.5	sx	22.0	32.5	36.5

Occurrence of the *Festucetalia vaginatae* species is neraly the same as that of the asteno-xerophyta. This is the situation in the case of *Festucion vaginatae, Festuco-Brometea, Festuco-Bromea,* and *Festucetalia valesiacae* (numerical data in Table 3).

Seasonal dynamics of phytomass production was also investigated (KÖRMÖCZI et al., 1980). Phytomass production of the moss and lichen synusium was investigated in the IBP (VERSEGHY et al., 1971).

Potentillo-Festucetum pseudovinae danubiale BODRK. 59

In the Hungarian Plain this association covers the pastures on sand soils of the brown (chernozem) type (BODROGKÖZY, 1959). Two possibilities of its origin may be considered. The *Potentillo-Festucetum pseudovinae danubiale* BODRK. 59 can be taken as a degraded *Festucetum vaginatae danubiale* Soó 29 degraded by biotic factors: excessive grazing which increase the effectivity other injuring factors (SIMON, 1971). But it can be considered also as a result of a positive succession. Due to favourable ecological processes species with competitive superiority entered *Festucetum vaginatae danubiale* and so its characteristic species have been ousted.

The study area was very adequate to clear the problem. In transitory cenoses *Festucion vaginatae* and *Festucetalia vaginatae* species still occur. Humus content in the layer A is about 2 per cent and till 40 cm it remains over 1 per cent. In the mechanical analysis also a fraction of smaller than 0.02 mm could be demonstrated (Fig. 3).

In Bugac the most common variant of the association is the *Potentillo-Festucetum pseudovinae cynodontetosum* Soó 55.

Soil-ecology. On the basis of investigation of two profiles it was established that its nutrient and water supply is more favourable than that of the former, transitory type. Layer A contains no $CaCO_3$ and the $CaCO_3$ content of the deeper layers is also low. In the profile No. 2. at 40 cm a buried humus containing layer was established. Taking into consideration the changes of organic matter in the profile it can be supposed that here the sand hills were formed gradually through a long period. The for-

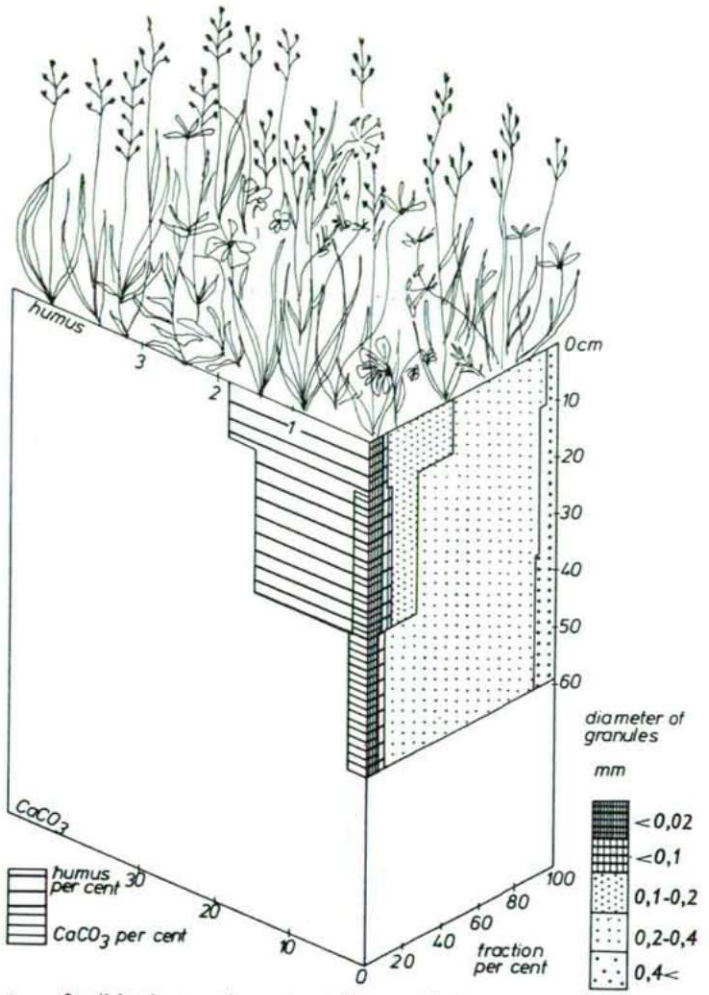


Fig. 3. Characters of soil in the transitory type of *Potentillo-Festucetum speudovinae*.

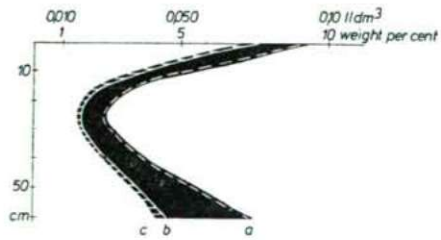


Fig. 4. Dynamics of soil humidity as expressed in weight per volume (a), in per cent of dry weight (b) and in per cent of wet weight (c) in the transitory type of *Potentillo-Festucetum pseudovinae*.

med and thereafter by blown sand buried grass stands resulted the humus containing layers. The mechanical analysis showed no significant differences in the different layers (Fig. 5. and 6).

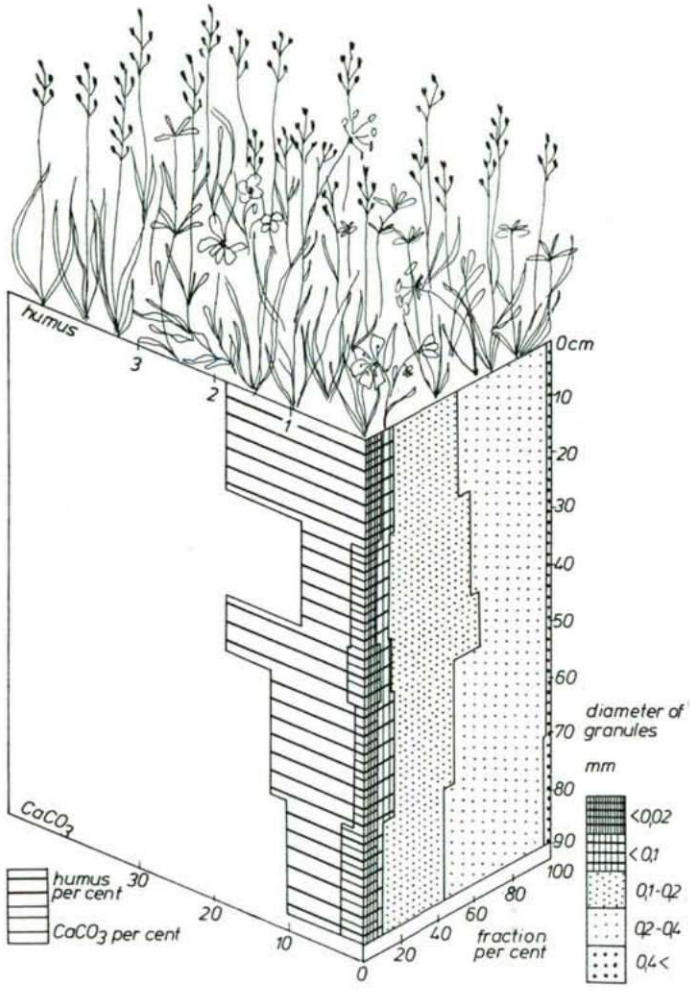


Fig. 5. Characters of the soil of a *Festuca pseudovina* stand with humus layer in the depth

The fall of 1979 scanty in rain fall showed its effect in water content of the different soil layers. In layer A (zone of the roots) it was nearly the double that of the soil of *Festucetum vaginatae* (Fig. 7).

Analysing the cenosystematical and hydro-ecological characters of the species it was established that also mesophyta and with low dominancy even meso-hygrophyta (*Molinio-Arrhenatheretea* and *Arrhenatheretalia* species) are represented. Meso-

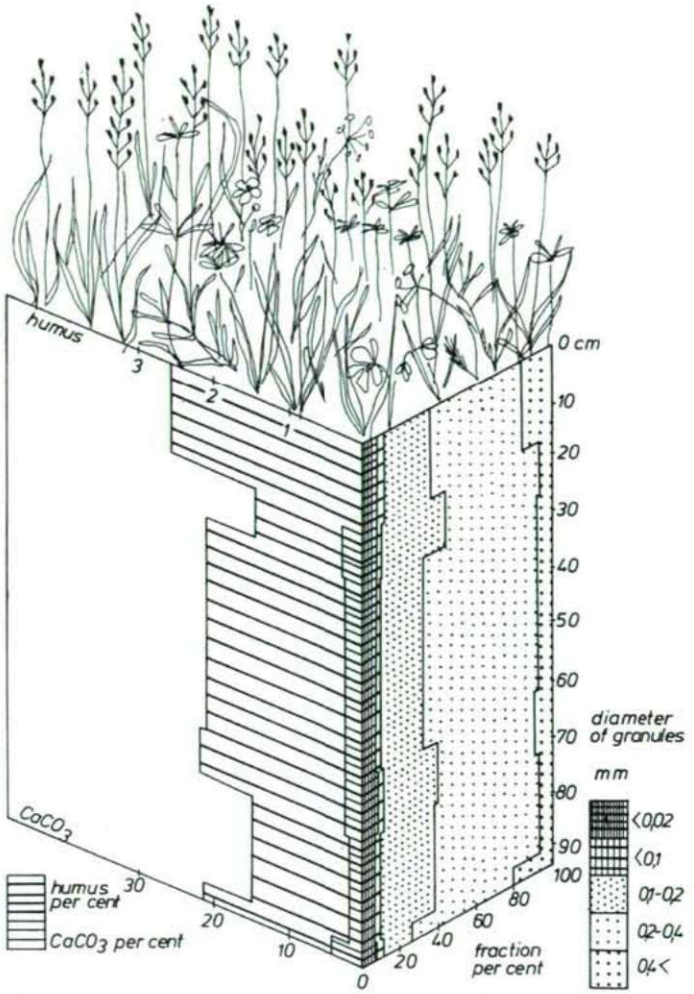


Fig. 6. Soil profile with high humus contents of a *Festuca pseudovina* stand.

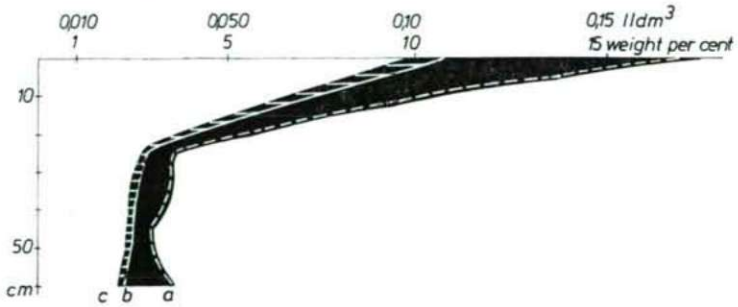
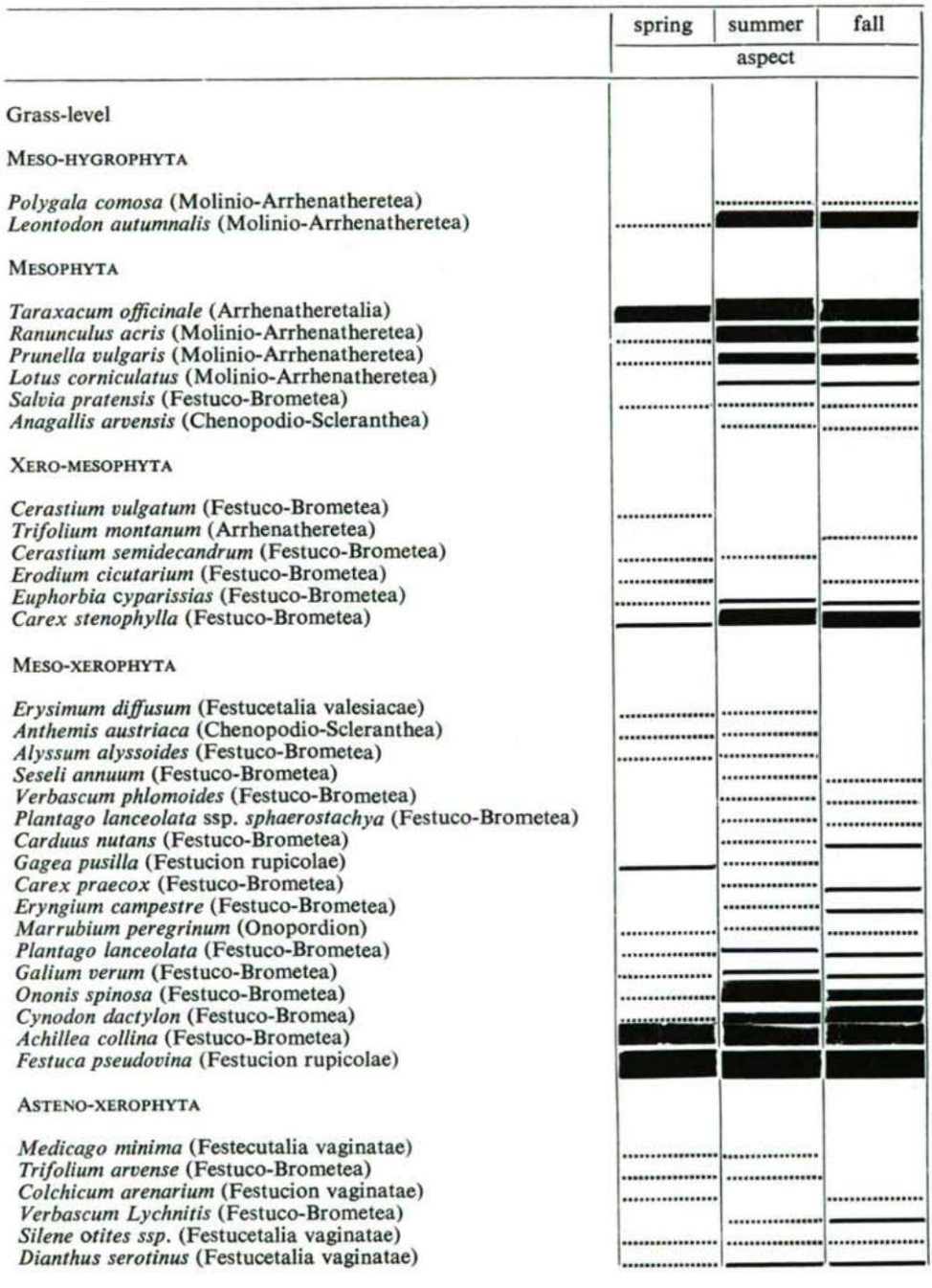


Fig. 7. Dynamics of soil humidity of the profile of Fig. 6. in fall meagre of precipitation.

Table 4. Potentillo-Festucetum pseudovinae dannbiale



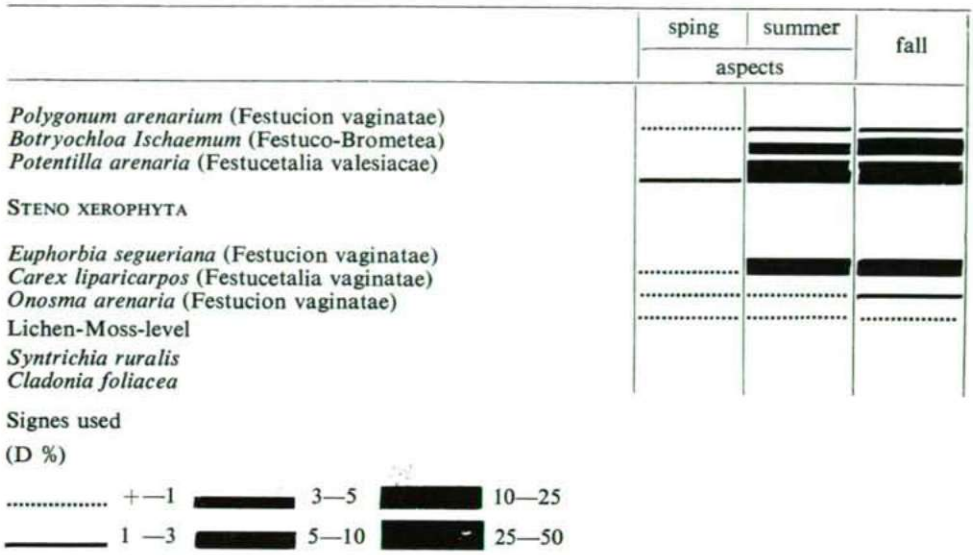


Table 5. Grouping the stand according to the number of species

	sumber of species		percent		number of species		per-cent
Molinio-Arrhenatheretea	5			mhg	2		
Arrhenatheretalia	1	7	15.9			8	18.2
Arrhenatheretea	1			m	6		
Festucion valesiacae							
Festucion rupicolae	2						
		5	11.3	xm	6		
Festucetalia valesiacae	3						
						24	54.6
Festuco-Brometea							
Festuco-Bromea	25	25	56.9	mx	18		
Onopordion							
Chenopodio-Scleranthea							
Festucetalia vaginatae	3		15.9	ax	9		
		7				12	27.2
Festucion vaginatae	4			sx	3		

xerophyta are permanently dominant from the spring aspect (over 50 per cent). The composing species are mostly the *Festucion rupicolae, Festucetalia valesiacae* and *Festuco-Brometea* species. Number of species and connections with the hydro-ecological groups are seen in Tables 5. and 6.

It is striking also, however, that some asteno-xerophyta and steno-xerophyta remain in this stand if only threadwise. It may be supposed that they come from the

Table 6. Distribution of the species of *Potentillo-Festucetum pseudovioae* into ceno-systematic and hydro-ecologic groups according to dominancy in the three aspects

	spring	summer	fall		spring	summer	fall
	aspect				aspect		
Mol.-Arrhenatheretea	1.5	7.0	6.5	mhg	0.5	2.5	2.5
Arrhenatheretalia	3.0	5.0	5.5				
Arrhenatheretea	0.5			m	4.5	10.5	10.0
Festucion valesiacae	0.5		0.5	xm	3.5	3.5	4.0
Festucion rupicolae	41.0	40.5	40.0				
Festucetalia valesiacae	20.5	10.5	10.0	mx	53.0	59.5	60.0
Festuco-Brometea	15.0	24.0	23.5				
Festuco-Bromea	0.5	2.0	5.0				
Onopordion + Chen.-Scler.	1.0	1.5	1.0				
Festucetalia vaginatae	1.0	1.5	1.5	ax	24.0	16.5	18.0
Festucion vaginatae	2.5	4.0	5.0	st	1.5	3.0	3.5

neighbouring *Festucetum vaginatae* stands which are sometimes mosaic-like inserted. The favourable ecological characters and humus content of the sandy soil exclude the possibility of the survival of less competitive *Festucetalia* species of the steno-xerophyta group.

Seasonal dynamics of the phytomass production was also investigated (KÖRMÖCZI et al., 1980).

Lolio-Potentilletum anserinae (RPCS. 27) KNAPP 46

This association occurs in small spots on deeper sites between the hills. Due to subsiding the water table this association gradually becomes dry and considerable changes occur in its species composition.

Soil-ecology. Organic matter is 4 per cent in the zone of the roots and even at 80 cm it is neraly 1 per cent. In contrast to the soil deficient in lime of the former two stands here in the layer A more than 16 per cent and in the deeper layers nearly 32 per cent $CaCO_3$ can be demonstrated. Lime was most probably eluviated from the soil of the ridges accumulated here (Fig. 8).

In the mechanical analysis the loam-clay fraction was considerably higher than in the former stands. The high clay-content below 70 cm is the consequence of lime accumulation.

In Figure 9. the water content in the soil profile expressed as dry weight per cent, as wet weight per cent and as volume per cent (l/dm^3) demonstrates the situation of water supply in the fall scanty of rain falls. The sharp decrease fo humidity in the zone of the roots may be connected with the intensive transpiration of the plants. However, water moving from the underground table has a favourable effect.

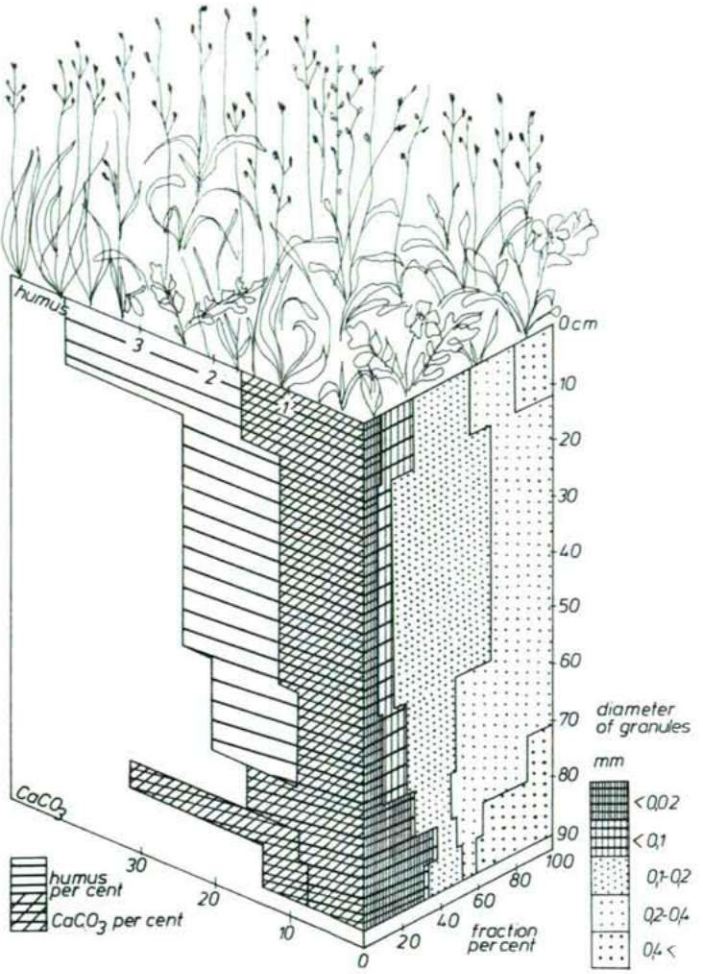


Fig. 8. Characters of the limey sand with a humus layer in the depth of *Lolio-Potentilletum anserinae*.

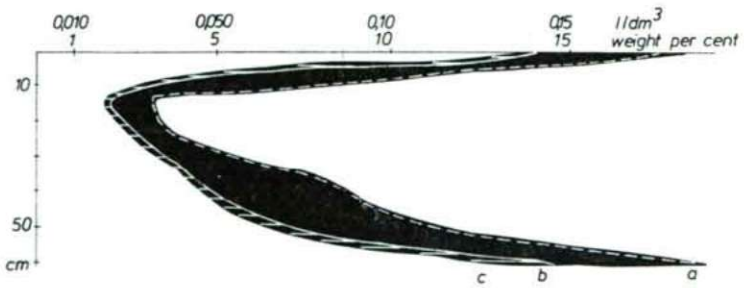


Fig. 9. Dynamics of soil humidity as expressed in weight per volume (a), in per cent of dry weight (b) and per cent of wet weight (c) in the humid sandy pasture during the fall.

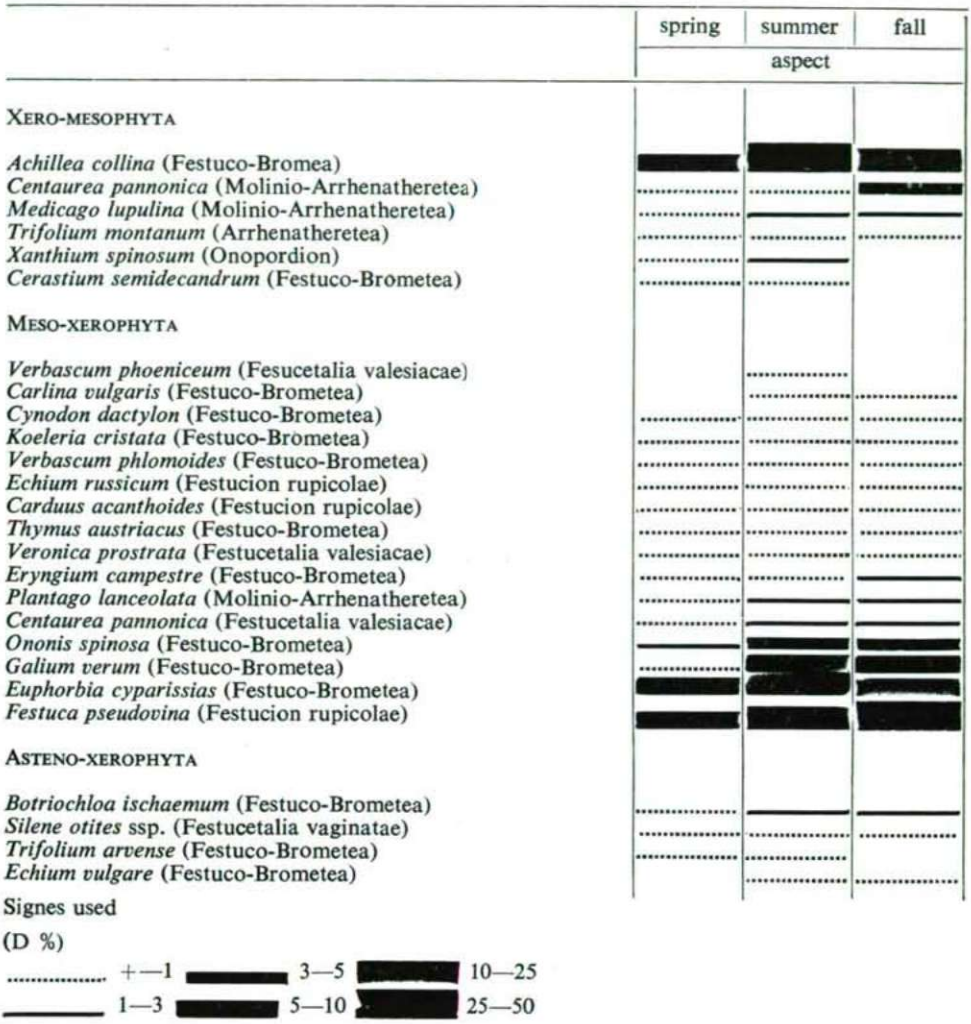
Analysing the phytocenoses some conclusions can be drawned concerning the genesis of the stand. Some helo-hygrophyta character species of the marsh-meadows as *Serratula tinctoria, Molinia coerulea, Mentha aquatica* can attain 8—10 per cent dominancy in the summer and in the fall. In first line to the more favourable soil-ecological properties can be attributed the close correlation between the number of species and dominancy of species belonging to the different sub-groups of the hygrophyta and species groups inside the *Molinio-Arrhenatheretea.*

Prevailing of species with wider ecological adaptability (frequently considered as indifferent species) from the *Festuco-Bromea* may be contributed to grazing and trodding, as in the former stands. It is to be pointed out, however, that the xero-mesophyta and meso-xerophyta are represented with a high number of species, but except some of them (e.g. *Festuca pseudovina, Achillea collina, Ononis spinosa, Euphorbia cyparissias, Galium verum* etc.) they occur only threadwise or with a very low dominancy (Tables 7, 8, and 9).

Results concerning phytomass production of *Lolio-Potentilletum anserinae* KNAPP 46 are also published (KÖRMÖCZI et al., 1980).

Table 7. Lolio-Potentilletum anserioae

	spring	summer	fall
	aspect		
Grass-level			
HELO-HYGROPHYTA			
Serratula tinctoria (Molinio-Arrhenatheretea)		.....	.....
Mentha aquatica (Molinio-Arrhenatheretea)	———	■■■	■■■
Molinia coerulea (Molinion)	.....	■■■	■■■
HYGROPHYTA			
Potentilla anserina (Molinietalia)	■■■	■■■	■■■
Potentilla reptans (Molinio-Arrhenatheretea)	———	■■■	———
Carex distans (Molinio-Juncetea)	.....	.....	.....
MESO-HYGROPHYTA			
Festuca pratensis (Molinio-Arrhenatheretea)	.....	■■■	■■■
Poa trivialis (Molinio-Arrhenatheretea)	.....	.....	———
Tetragonolobus maritimus (Molinietalia)	.....	.....	.....
Althaea officinalis (Agropyro-Rumicion)	.....	.....	.....
Polygala comosa (Molinio-Arrhenatheretea)	.....	■■■	———
MESOPHYTA			
Prunella vulgaris (Molinio-Arrhenatheretea)	■■■	■■■	■■■
Lotus corniculatus (Molinio-Arrhenatheretea)	———	■■■	■■■
Ranunculus acris (Molinio-Arrhenatheretea)	.....	———	———
Lolium perenne (Plantaginetalia)	.....	.....	.....
Salvia pratensis (Festuco-Brometea)	.....	.....	.....
Taraxacum officinale (Molinio-Arrhenatheretea)	.....	.....	.....
Leontodon autumnalis (Molinio-Arrhenatheretea)		.....	.....



Molinio-Salicetum rosmarinifoliae
(MAGYAR 33) Soó 57 *festucetosum pseudovinae* (Soó 57) n.n.

In the area this association occurs only fragmentary on the deeper sites between the hills.

Inland drainage and long, intensive pasturing considerably modified the original ecosystem. Today, only the most resistant species of the marsh survived. On other places between the Danube and Tisza where (KOVÁCS, 1962) the soil-ecological characters are less favourable degradation leads to some subassociation of *Festucetum vaginatae*. In our study area a different change occured.

Table 8. Grouping the stand according to the number of species

	number of species		per-cent			number of species		per-cent
Molinio-Juncetea	1				hhg	3		
Molinion, Molinietalia	3	18	41.0		hg	3	18	41.0
Molinio-Arrhenatheretea	13				mhg	5		
Arrhenatheretea	1				m	7		
Festucion rupicolae	3	6	13.4		xm	6	22	50.0
Festucetalia valesiacae	3							
Festuco-Brometea	16	16	36.4		mx	16		
Onopordion, Plantaginetea	3	3	7.0					
Festucetalia vaginatae	1	1	2.2		ax	4	4	9.0

Table 9. Distribution of the species of *Lolio-Potentilletum anserinae* into ceno-systematic and hydro-ecologic groups according to dominancy in the three aspects

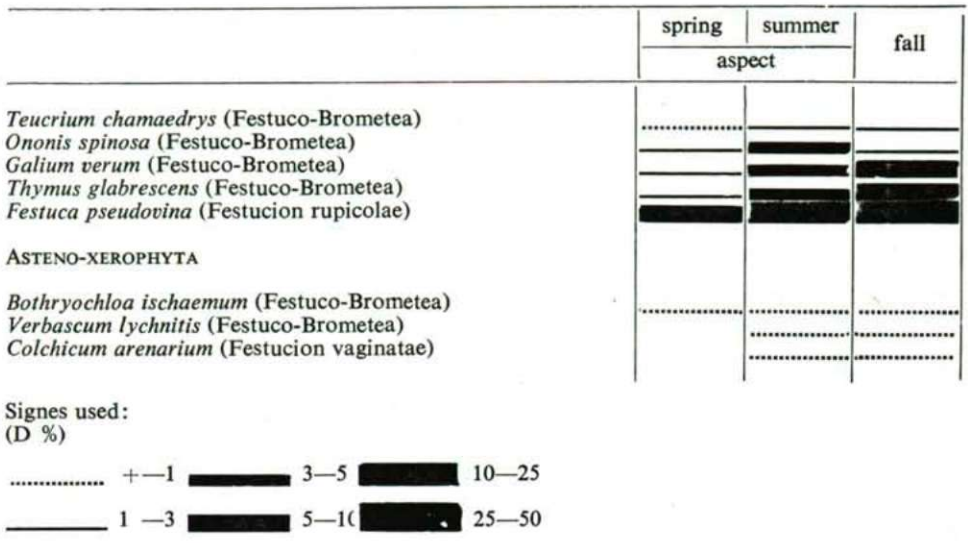
	spring	summer	fall			spring	summer	fall	
	aspect					aspect			
Mol.-Juncetea	0.5	0.5	0.5		hhg	1.5	8.5	8.5	
Molinion + Molinietalia	11.0	20.5	10.5						
Mol.-Arrhenatheretea	9.0	21.5	21.5		hg	11.5	17.5	6.5	
Arrhenatheretea	0.5	0.5	0.5						
					mgh	2.5	6.5	6.0	
Festucion rupicolae	21.0	26.0	31.0		xm	17.5	18.5	18.5	
Festucetalia valesiacae	1.0	2.0	1.5						
Festuco-Brometea	12.5	25.0	28.5						
Festuco-Bromea					mx	28.5	41.0	45.0	
Onopordion, Plantaginetea									
Agropyro-Rumicion	1.5	2.0	1.5						
Festucetalia vaginatae	0.5	0.5	0.5		ax	1.5	2.5	2.0	

The ecological circumstances are similar to that of the former stand it formes isles in it. Here can be observed with some per cent dominancy also *Schoenus nigricans*, character species of *Schoenetum nigricantis* (ALL. 22) W. KOCH 26 showing the genesis of the stand.

Although in the species spectrum occur some character species of the association and association group (e.g. *Molinia coerulea, Salix rosmarinifolia, Serratula tinctoria, Cirsium canum* etc.), the changed ecological factors are no longer favourable to the species of the different subgroups of the hygrophyta. The drying up site and intensive grazing favour the same meso-xerophyta species as in the case of *Lolio-Potentilletum anserinae*. So became numerous *Festuca pseudovina, Poa angustifolia, Ononis spinosa, Galium verum* — as in the former stand; they can be considered as differential species (Table 10).

It may be supposed that the regression and elimination of *Molinion, Molinietalia* and *Molinio-Arrhenatheretea* species show a change in the direction of some associa-

Table 10. Molinio-Salicetum rosmarinifoliae



tion of *Festucion rupicolae* or *Agropyro-Rumicion*. Good correlations were demonstrated also in the different aspects in number of species (Table 11) and dominancy (Table 12) between cenosystematic groups and hydro-ecologic groups of the relics of the marsh vegetation.

Table 11. Distribution of the species number of the stand into ceno-systematic and hydro-ecologic groups

	number of species		per cent		number of species		per cent
Eriophorion	1	3	7.1		hhg	5	11.7
Molinio-Juncetea	2						
Molinion, Molinietalia	5	5	12.2		hg	2	4.8
Molinio-Arrhenatheretea	3	4	9.6		mhg	4	9.6
Agropyro-Rumicion	1						
Arrhenatherion	2						
Arrhenatheretalia		3	7.1		m	6	14.3
Arrhenatheretea	1						
Festucion rupicolae	1						
Festucetalia valesiacae	4	5	11.6		xm	3	7.1
Festuco-Brometea							
Festuco-Bromea	16	19	45.3		mx	19	45.3
Onopordion, Plantaginetea	3						
Chenopodio-Scleranthea							
Festucion vaginatae	3	3	7.1		ax	3	7.1

Table 12. Distribution of the species of *Molinio-Salicetum rosmarinifoliae* into ceno-systematic and hydro-ecologic groups according to dominancy in the different aspects

	spring	summer	fall		spring	summer	fall	
	aspect				aspect			
Eriophorion								
Mol.-Juncetea	5.5	7.0	4.0		hhg	11.5	14.0	10.0
Molinion	7.0	10.0	10.0		hg	3.0	8.5	11.0
Molinietalia								
Mol.-Arrhenatheretea	4.5	9.0	14.5					
Agropyro-Rumicion	5.0	8.0	10.0		mhg	6.0	9.5	6.5
Arrhenatherion								
Arrhenatheretalia	0.5	3.0	5.0					
Arrhenatheretea	0.5	1.5	1.5		m	6.0	11.0	4.0
Festucetalia valesiacae								
Festucetalia rupicolae	23.5	21.0	28.0		xm	2.5	3.5	5.5
Festuco-Brometea								
Festuco-Bromea	14.5	19.0	24.0		mx	34.5	36.5	52.0
Onopordion, Plantaginetea	1.5	1.0	1.5					
Chenopodio-Scleranthea								
Festucion vaginatae	6.5	5.0	4.0		ax	1.5	2.0	2.5

References

BALLENEGGER R. (1953): Talajvizsgálati módszerkönyv (Handbook of soil examination methods). — Budapest.

BODROGKÖZY, GY. (1957): Die Vegetation der Weisspappel-Haine in dem Reservat "Emlékerdő" bei Szeged—Ásotthalom. — Acta Biol. Szeged. *3*, 127—140.

BODROGKÖZY, GY. (1977): A Pannonicum halophyton társulásainak rendszere és synökologiája. — (Kand. Ért. Tézisei).

BODROGKÖZY GY. (1978): Összefüggések a különböző növényállományok hidroökológiai csoportjai és talajuk komplex módon értékelt jellemzői között (kézirat).

KOVÁCS-LÁNG, E. and SZABÓ, M. (1971): Changes of soil humidity and its correlation to phytomass production in sandy meadov associations. — Annal. Univ. Sci. Budapest, Sect. Biol. *13*, 115—126.

KOVÁCS, M. (1962): Die Moorwiesen Ungarns. — Budapest.

KÖRMÖCZI, L., BODROGKÖZY, GY. and HORVÁTH, I. (1981): Investigation of biological production and bioclimate of sandy grasslands in Bugac (Great Hungarian Plain between Danube and Tisza). — Acta Biol. Szeged. *17*. 55—69.

SIMON T. (1971): A csévharaszti természetvédelmi és IBP mintaterület (The nature reserve and IBP Samling area of Csévharaszt). — Állattani Közl. *58*, 105—111.

SZABÓ M. (1975): Két homoki növénytársulás talajának vízgazdálkodása a csévharaszti IBP mintaterületen. — Annal. Univ. Sci. Budapest, Sect. Biol. *17*, 101—111.

SZODFRIDT, I. and FARAGÓ, S. (1968): Talajvíz és vegetáció kapcsolata a Duna—Tisza köze homokterületén (Zusammenhang zwischen Grundwasser und Vegetation in Donau—Theiss Sandgebiet). — Bot. Közlem. *55*, 69—75.

SZODFRIDT I. (1971): Vízbeszivárgási vizsgálatok a Duna—Tisza közén. — Erd. Kutatások *67*, 5—20.

SZODFRIDT I. (1974): Vízgazdálkodási vizsgálatok homoki talajokon — Abstracta Bot. *2*, 43—46.

Soó R. (1964): A magyar flóra és vegetáció rendszertani-növényföldrajzi kézikönyve I—VI (Synopsis systematico-geobotanica florae vegetationisque Hungariae I—VI). — Budapest.
Stefanovits P. (1956): Magyarország talajai (Soil of Hungary) — Budapest.
Verseghy, K. and K. Láng, E. (1971): Investigations on production of grasland communities of sandy soil in the IBP area near Csévharaszt (Hungary). — Acta Biol. Acad. Sci. Hung. *22*, 393—411.

Address of the authors:
Dr. Gy. Bodrogközy
Gyöngyi Farkas
Department of Botany, A. J. University,
H-6701 Szeged, P. O. Box 428. Hungary

Acta Biologica Szeged. 27 (1—4), pp. 55—69 (1981)

INVESTIGATION OF BIOLOGICAL PRODUCTION AND BIOCLIMATE OF SANDY GRASSLANDS IN BUGAC (GREAT HUNGARIAN PLAIN BETWEEN DANUBE AND TISZA)

L. KÖRMÖCZI, GY. BODROGKÖZY and †I. HORVÁTH

Department of Botany, Attila József University, Szeged
(Received June 20, 1980)

Summary

A three year period of investigations was performed in the sandy pasture near Bugac in the Kiskúnság National Park beginning with 1977. On the area covered with sand hills the vegetation show a mosaic-like distribution according to the various environmental factors determined by differences in the relief. Dynamics of production and bio-cilmate of five plant associations were investigated. The most extreme micro-climate was found in the *Bromus tectorum* stands and in the association *Festucetum vaginatae danubiale* Soó 29 with low degree of cover on the ridges of the sand hills in semiarid years. At this time production of phyto-mass showed a curve with two maxima. A different bio-climate was observed in the more densely covering grasses between the sand hills where vegetation was favourably influenced by better water supply, in the associations *Potentillo-Festucetum pseudovinae danubiale* BODRK. 59 and mainly in the *Lolio-Potentilletum anserinae* (RAPCS. 27) KNAPP 46 and *Molinio-Salicetum rosmarinifoliae* (MAGYAR 33) Soó 57 stands. In these cases dynamics of the production showed a curve with one maximum. The dry mass of the roots is everywhere 85—90 percent of the total dry matter.

Introduction

The biocenological and ecological investigations of the area are going on from 1976.

The mosaic complex of the vegetation enabled us to investigate the bio-climatological role of the vegetation and the relief, and the comparison of the primary production of the different associations and their dynamics. The data of these investigations furnish a reliable basis for the parallel running zoological investigations, concerning in first line the dynamics of the food chains and their energetics. Synthetizing the results a good picture can be obtained about the dynamics of the ecosystems of the sandy sites.

Present paper evaluates the results of the complex investigations of bio-climate and bio-production.

Relatively few data are available about micro-climate of the sandy areas between the Danube and Tisza. There are known the results of MAGYAR (1935) and HARGITAI (1942) about the forests of the area. Latter author compared the micro-climate of the sparsely covered sand hill ridges and that of the densely covered areas. The values obtained are characteristic to the associations. The temperature of air was measured in forests, clearings and pastures and data were published about the stratification of

temperature by NAGY (1972). Complex bio-production investigations have been performed in Hungary since the middle of the sixties covering several themes of the International Biological Program (IBP). The papers of KOVÁCS-LÁNG (1971, 1974), KOVÁCS-LÁNG and SZABÓ (1971, 1973), SIMON and KOVÁCS-LÁNG (1972) discuss production-dynamics, its ecological determinants and mathematical problems of the study area Csévharaszt (in the middle of the area between Danube and Tisza). Papers of KOVÁCS-LÁNG and SZABÓ and SIMON and KOVÁCS-LÁNG describe the productivity of the annual and perennial sandy grasses demonstrating the dynamics of the production with two maxima during the vegetative period and connections between productivity relative humidity of air and insolation and temperature.

Materials and Methods

The study area on the eastern part of the Bócsa—Bugac region of the Kiskúnság National Park was fenced to keep off grazing animals. The ridges of the sand hills and the depressions between them have a NW-SE orientation. Differences in level are in general 1.5—2.0 m, the highest and lowest points differ 2.8 m.

On the highest sites occur *Festucetum vaginatae danubiale normale* (MAGYAR 33, KÁRPÁTI I. 54), the degraded *Potentillo-Festucetum pseudovinae danubiale euphorbietosum seguerianae* BODRK. 59 and its *Bromus tectorum* faces, between the hills the *Festuca pseudovina* facies of *Lolio-Potentilletum anserinae* KNAPP 46 while in the deepest sites as remains of extinct marshes the *Festuca pseudovina* facies of *Molinio-Salicetum rosmarinifoliae* (detailed descriptions in BODROGKÖZY and FARKAS 1981).

Plant production was determined by monthly harvesting 30×30 cm squares in three repetition during the vegetative period. The harvested matter was separated in four fractions: living monocotyledonous and living dicotyledonous plants, mosses and lichens, and dead matter. Plant material in the soil was determined by washing out monolithes of 10×10×20 cm. The separated plant materials were dried at 90 °C and the dry matter weight measured.

Bio-climate measurments of the four plant stands (Fig. 1) were performed with the aid of a laboratory-car. Air and soil temperatures were measured with a platinum resistance thermometer (in the air at 10, 180, 350 cm and according to the height of the plants at two more levels, in the soil at 2, 5 and 10 cm deep) through 22—25 hours; nights beeing in the middle of this period. Relative humidity of air was measured by Assmann aspiration psychrometer.

Meteorological data of the three years came from the local station. (Fig. 3.) The climate was characterized by the fifty year means of the meteorological station of Kecskemét, this being the nearest to the study area (Fig. 2). As shown, the climate is continental with hot summers. This distribution of the precipitation is uneven, the falls are generally arid while the summers are variable in this respect.

Results and discussion

The three years of investigation were especially adequate to demonstrate the influence of weather conditions on dynamics of dominancy and of production. 1977 was meagre in rainfall from April, 1978 was rich in precipitation while 1979 had a middle position in this respect showing a rainfall maximum in May-June characteristic to the Hungarian climate.

Organic matter productivity and bio-climate of the four stands can be summarized as follows:

Festucetum vaginatae danubiale normale (MAGYAR 33, KÁRPÁTI I. 54) has a covering of 40—50 per cent. The plants remain short, even in the early summer less than 30 cm in average. According to the recorders of station number II. here were measured the most extreme temperatures. The fluctuations were the highest (daily 27—32 °C) in the lower and higher air layers, the greatest differences from the other

stands being observed at 30 cm due to the uncovered sand surfaces. The highest temperatures were measured at 13—14 hours p.m., the lowest at 5—7 hours a.m., depending on the season. Also in this scanty covered site was measured the lowest relative air humidity: 40—50 per cent.

The little-maximum of formation of dew was striking; independently of the season it occurred between 0 and 2 hours, not only here but in the other stands too (Fig. 4).

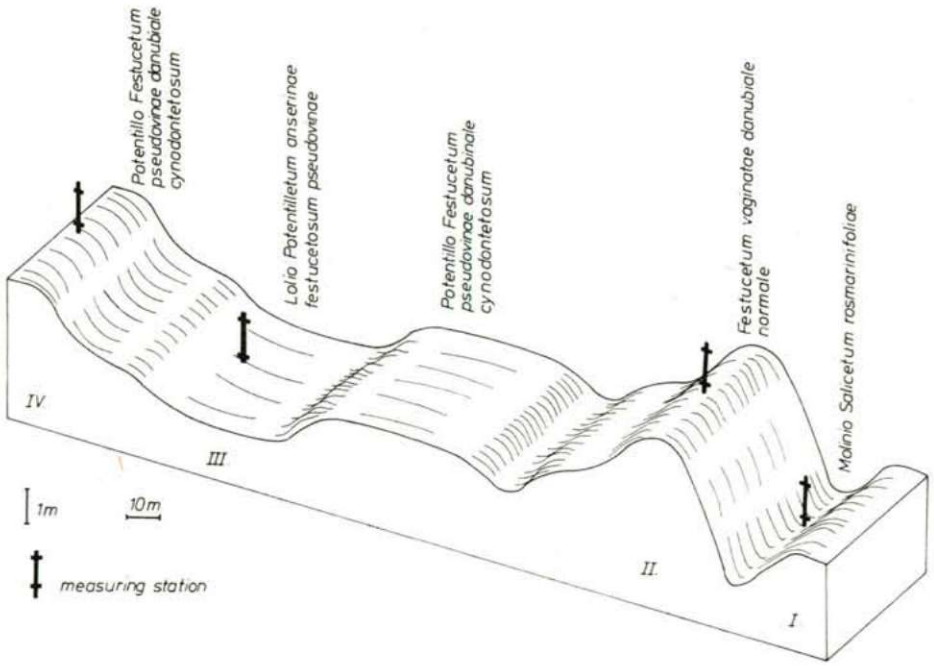


Fig. 1. Relief section of the study area in Bugacpuszta; situation of the plant associations and the bioclimatological stations.

Due to the low thermal conductivity of sand, fluctuation of temperature was considerably lower at 10 cm depth than on the surface or at 2 cm depth.

Dynamics of primary production

In the arid year (1977) organic matter production showed two maxima because in the summer meagre in rainfall the vegetation dried out (SIMON and KOVÁCS-LÁNG, 1972). In 1978 the regress of phytomass (negative production) was not expressed due to the rainfall maximum in June; positiv production, however, was not observed. This latter can be attributed to biogeneous factors. The study area, however exempted of pasturing, was invaded in the early summer by locusts which consumed a considerable part of the Gramineae species. This supposition was supported by the investigations of KISS (1979) on the seasonal dynamics of orthopterean nymphs. Their number showed a maximum at the end of May and beginning of June, their number in the

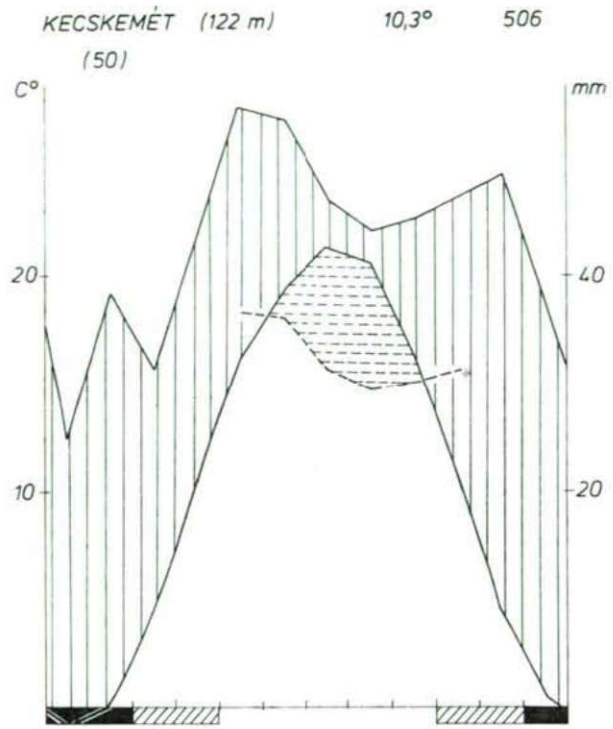


Fig. 2. Walter-Lieth diagram of Kecskemét based on the fifty-yeras mean of temperature and precipitation values.

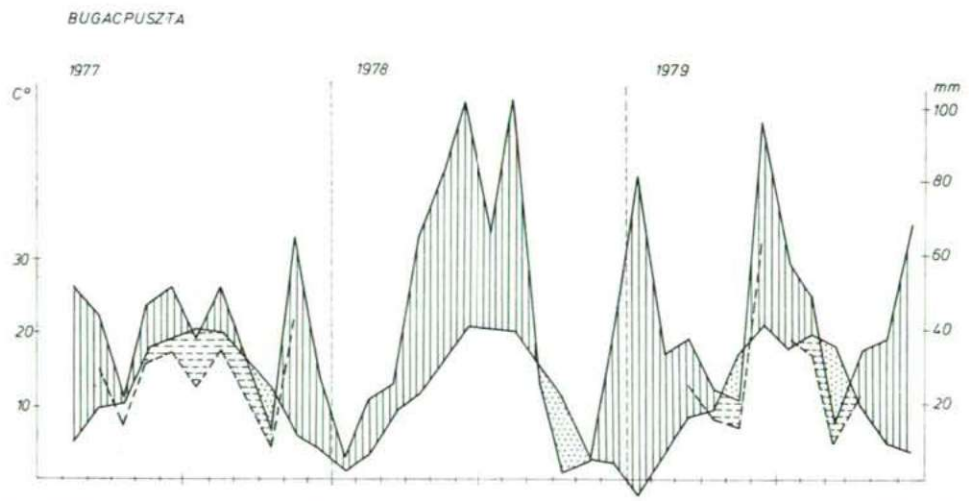


Fig. 3. Dynamics of temperature and precipitation during the three years of investigation (1977—79).

Festuca vaginata stands was 2.5 times more than that of counted in the stands of lower sites.

Potentillo-Festucetum pseudovinae Soó 39/50 *euphorbietusom seguerianae* BODRK. 59 *Bromus tectorum* facies.

It can be considered as a fase in the succession after Festucetum vaginatae which was degraded by intensive pasturing (BODROGKÖZY and FARKAS, 1981). Its dominancy conditions are more favourable than those of *Festucetum vaginatae*. Its phytomass production was higher than in the *Festucetum vaginatae* especially in the early summer.

Potentillo-Festucetum pseudovinae Soó 39/50 *cynodontetosum*

It occurs at more favourable levels than the former (Fig. 1). From the composing species predominates *Cynodon dactylon* which endure grazing and trodding, having wide ecological adaptability. *Cynodon* can be considered as a differentiating species. Being the dominant species it produces the greater part of organic matter. In the neighborhood of the study area this is the most frequent association. Therefore production biology data obtained may be used in practice too.

Its bio-climate is better than that of the former association; it may be considered as a different type. Due to the more closed growth warming up and cooling down is not so extreme as in the former association. The dynamics of temperature as regarded time of maximum minimum and little-maximum are similar but daily fluctuation is only 20—24 °C. The realtive humidity of air is higher. Dynamics oftemperature in *Potentillo-Festucetum pseudovinae* is shown in Figure 5.

Overground phytomass production

From the enviromental factors precipitation was the first the changes of which showed a close correlation to seasonal dynamics of living matter production.

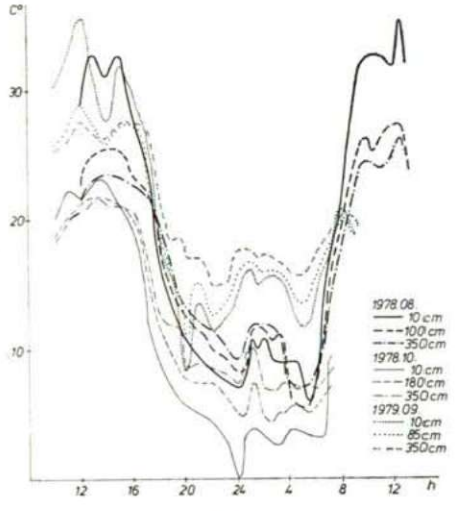


Fig. 4

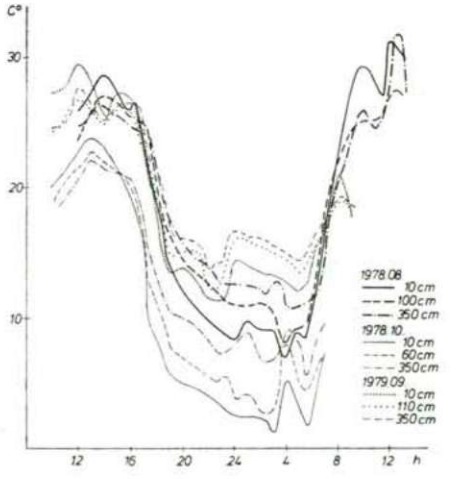


Fig. 5

Fig. 4. Dynamics of temperature in *Festucetum vaginatae* danubiale at different hights and dates.

Fig. 5. Dynamics of temperature in *Potentillo-Festucetum pseudovinae danubiale*.

Table 1. Dynamics of phytomass production of the stand

Overground phytomass g/m²

Date	Monocotyl.	Dicotyl.	Phanerogam. total	Moss-lichen	Living total	Dead	Total
07.04.77..	23.3	29.6	52.9	31.7	84.6	67.1	151.6
05.05.	58.0	31.1	89.3	12.3	101.6	73.0	174.7
28.07.	7.7	29.2	36.9	7.8	44.7	232.3	277.0
23.09.	18.6	26.8	45.4	12.8	58.2	218.3	276.5
27.10.	21.1	15.6	36.7	15.2	51.9	124.8	176.7
21.11.	17.8	3.7	21.5	51.5	73.0	137.0	210.0
21.04.78.	36.7	6.9	43.6	23.7	67.3	58.1	125.4
17.05.	41.9	65.2	107.1	37.4	144.5	154.1	298.6
10.07.	34.8	51.7	86.5	209.8	296.3	75.2	371.5
13.10.	35.2	19.8	55.0	5.7	60.7	102.2	162.9
15.11.	13.7	5.9	19.6	—	19.6	99.3	118.9
16.02.79	16.7	16.3	33.0	110.0	133.0	298.5	431.5
23.03.	38.9	10.0	48.9	16.7	65.6	255.6	321.2
27.04.	35.1	8.7	43.8	100.4	144.2	167.4	311.6
18.05.	84.1	2.1	86.2	8.0	94.2	209.6	303.8
26.06.	26.0	—	26.0	39.6	65.6	164.1	229.7
15.09.	128.5	19.6	148.1	82.2	230.3	296.7	527.0
18.10.	118.2	14.5	132.7	330.3	452.0	190.8	642.8

Underground phytomass g/m²

Date	0—5 cm	5—10 cm	10—20 cm	Total
07.04.77.	490	250	40	780
05.05.	1190	330	250	1770
23.09.	1530	310	370	2210
27.10.	1990	250	360	2600
21.11.	1400	500	250	2150
23.03.79.	1960	300	360	2620
27.04.	1150	160	90	1400
18.05.	700	310	290	1300
26.06.	1320	360	370	2050
18.10.	960	220	190	1370

Table 2. Productivity of the stand g/m² day

Date						
77.		07.04- 05.05. 1.30	05.05- 28.07. -0.63	28.07- 23.09. 0.15	23.09- 27.10. -0.26	27.10- 21.11. -0.61
78.			21.04- 17.05. 2.44	17.05- 10.07. -0.38	10.07- 13.10. -0.33	13.10- 15.11. -1.07
79.	16.02- 23.03. 0.45	23.03- 27.04. -0.15	27.04- 18.05. 2.02	18.05- 26.06. -1.52	26.06- 15.09. 1.50	15.09- 18.10. -0.45

Table 3. Seasonal dynamics of the overground phytomass (g/m²) during the three years of investigation

Date	Monocotyl.	Dicotyl.	Phanerogam. total	Moss-lichen	Living total	Dead	Total
05.05.77.	90.1	72.4	162.5	10.6	173.1	108.6	281.7
28.07.	34.8	15.6	50.4	15.0	65.4	171.1	236.5
23.09.	21.5	12.2	33.7	18.9	52.6	98.9	151.5
27.10.	39.3	6.3	45.6	29.3	74.9	166.7	241.6
21.11.	30.8	7.8	37.8	22.6	60.4	180.0	240.4
21.04.78.	72.6	5.6	78.2	18.9	97.1	145.5	242.6
17.05.	115.6	31.1	146.7	36.1	182.8	138.1	320.9
10.07.	98.9	33.5	132.4	34.8	167.2	323.5	490.5
13.10.	33.7	—	33.7	23.3	57.0	250.0	307.0
15.11.	25.2	6.7	31.9	19.6	51.5	243.7	295.2
16.02.79.	27.0	—	27.0	78.5	10.5	197.0	302.5
23.03.	46.7	5.6	52.3	—	52.3	255.6	307.9
27.04.	178.2	4.1	182.3	37.0	219.3	343.7	563.0
18.05.	220.0	4.1	224.1	35.6	259.7	177.4	437.1
26.06.	25.9	3.7	29.6	21.5	51.1	245.5	296.6
15.09.	127.0	—	127.0	45.2	172.2	797.8	970 0
18.10.	68.1	3.0	71.1	47.8	118.9	340.4	459.3

Dynamics of the underground phytomass (g/m²)

Date	depth cm			Total
	0—5	5—10	10—20	
05.05.77.	1120	490	440	2050
23.09.	970	310	110	1390
27.10.	1780	320	540	2640
21.11.	750	530	270	1550
27.04.79.	1250	80	120	1450
18.05.	790	390	410	1590
26.06.	590	290	170	1050
18.10.	1660	170	230	1960

Table 4. Dynamics of productivity (g/m² day) in the Bromus tectorum facies

Date					
77.	07.04- 05.05. —	05.05- 28.07. -1.34	28.07- 23.09. -0.29	23.09- 27.10. 0.35	27.10- 21.11. -0.31
78.		21.04- 17.05. 2.63	17.05- 10.07. -0.27	10.07- 13.10. -1.40	13.10- 14.11. -0.06
79.	23.03- 27.04. 2.22	27.04- 18.05. 1.99	18.05- 26.06. -4.99	26.06- 15.09. 1.20	15.09- 18.10. -1.69

In 1977 the vegetative period was meagre in rainfall. The rather low maximum in the late spring-early summer was followed in the rainy fall by a second maximum, as in the *Bromus tectorum* facies. The dead matter fraction evenly increasing attained a maximum in October.

A close correlation was established between the summer precipitation maximum and phytomass production of *Cynodon* stands. The living matter maximum was in July while in the *Bromus* stands in May. In the fall meagre in precipitation productivity decreased to the fifth. The dead matter maximum was in November (in the *Bromus* facies in July) (Table 5).

Table 5. Seasonal dynamics of phytomass production in the stand with *Cynodon*
Overground phytomass g/m²

Date	Monocotyl.	Dicotyl.	Phanerogam. total	Moss-lichen	Living total	Dead	Total
07.04.77.	24.0	20.4	44.4	8.0	52.4	50.8	103.2
05.05.	39.7	33.2	72.9	2.1	75.0	65.9	140.9
28.07.	90.9	41.6	132.5	12.2	144.7	100.8	245.5
23.09.	31.9	31.1	63.0	1.9	64.9	126.3	191.2
27.10.	22.6	11.5	34.1	5.9	40.0	153.3	193.3
21.11	25.2	15.6	40.8	—	40.8	106.3	147.1
21.04.78.	41.2	3.0	44.2	8.3	52.5	136.5	189.0
17.05.	85.9	75.9	161.8	—	161.8	115.6	277.4
10.07.	110.0	71.3	181.3	30.3	211.7	159.1	370.8
13.10.	26.3	—	26.3	10.5	36.8	188.7	225.5
15.11.	11.1	0.5	11.6	4.0	15.6	190.9	206.5
16.02.79.	16.3	4.8	21.1	49.6	70.7	193.7	264.4
23.03.	47.8	6.7	54.5	26.7	81.2	262.2	343.4
27.04.	51.1	18.9	70.0	14.4	84.4	241.8	326.2
18.05.	120.4	15.2	135.6	0.7	136.3	164.8	301.1
26.06.	122.6	23.3	145.9	10.0	155.9	72.6	228.5
15.09.	204.8	23.7	228.5	6.3	234.8	187.0	421.8
18.10.	31.1	8.9	40.0	8.5	48.5	183.0	231.5

Underground phytomass g/m²

Date	0—5 cm	5—10 cm	10—20 cm	Total
07.04.77.	1240	160	170	1570
05.05.	1640	300	270	2210
23.09.	720	260	210	1190
27.10.	1120	660	430	2210
21.11.	1110	690	850	2650
23.03.79.	2720	730	560	4010
27.04.	3820	730	630	5180
18.05.	3060	750	570	4380
26.06.	930	590	470	1990
18.10.	410	210	200	820

To registrate the effect of the abundant precipitation of the following winter in February 1979 investigations were performed. According to these, from November 1978 till February 1979 the organic matter of the *Cynodon* stand became fourfold without any growth in the quantity of dead matter. In the vegetation period this surplus in precipitation was evenly used by the grass; the precipitation maximum in May being a favourable supply. Through these seasonal dynamics of organic matter production showed an evenly rising tendency. The fraction of living matter showed a maximum in September.

In the dry year the underground phytomass of *Cynodon* stand showed a dynamism of two maxima similar to that of the *Bromus* facies. The maximum of the underground parts follows that of the overground parts with a months delay due to regeneration of the roots of *Cynodon*.

In the more humide year of 1979 the roots of *Cynodon* were more respondent to the fluctuation of the precipitation than the overground parts. In the drier summer period following the May rich in precipitation in the 0—5 cm soil layer the root-mass decreased to one third. Negativ repoductivity was here more expressed than in the *Bromus* stand.

Table 6. Seasonal dynamics of productivity (g/m² day) in Potentillo-Festucetum pseudovinae cynodontetosum

Date						
77.		07.04- 05.05. 1.02	05.05- 28.07. 0.70	28.07- 23.09. -1.22	23.09- 27.10. -0.85	27.10- 21.11. 0.26
78.			21.04- 17.05. 4.52	17.05- 10.07. 0.36	10.07- 13.10. -1.63	13.10- 15.11. -0.44
79.	16.02- 23.03. 0.95	23.03- 27.04. 0.44	27.04- 18.05. 3.12	18.05- 26.06. 0.27	26.06- 15.09. 1.02	15.09- 18.10. -5.71

Lolio-Potentilletum anserinae KNAPP 46 *festucetosum pseudovinae* (n.n.)

This is the vegetation of the shallow sites between the hills. The soil is a humid sand covered by the vegetation till 100 per cent. Progressive desiccation leads to dominancy of *Festuca pseudovina* and this association is pastured in the region.

Its bio-climate is characterized by a lower temperature as compared with the former stands, espcially at nights. The difference is 3—4 °C. The depressions between the hills function as cold-traps: the air turned cold over the hills flows down and stagnates. So at the surface this sites became colder. On the other hand, irradiation reaches these sites later, warming up can be delayed 0.5—1 hour than on the ridges (Fig. 6). Seasonal dynamics of organic matter prodution was correlated with the dynamics of precipitation. In the dry 1977 production of the overground parts was similar to that of the *Cynodon* stands living higher: maximum of living matter was observed in the early summer, that of dead matter in the fall. This latter determined also the total production. Underground phytomass production showed two maxima in all

soil layers and it was more than twentyfold (179—4140 g per m^2) of the overground mass.

In the following humid year production dynamics of *Lolio-Potentilletum anserinae* was different. In contrast to the favourable water supply the maximum of the living matter fraction was hardly 30 per cent higher, while the dead matter having its maximum at the same time (early summer) was the fourfold of the previous year. This can be contributed to preclusion of grazing. It is stiking that humid weather accelerated decomposition of dead matter.

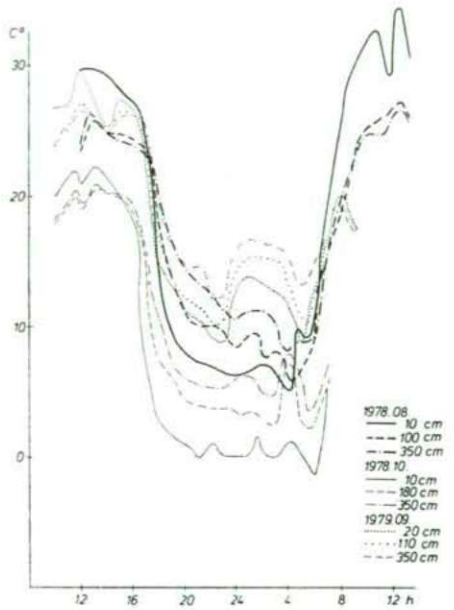


Fig. 6. Dynamics of temperature in *Lolio-Potentilletum anserinae* at different hights.

In 1979 precipitacion showed three maxima: winter, summer and fall. In this year the dry spring had a negativ effect on the dynamics of living fraction. So the maximum was transferred to the end of summer. Accumulation of the dead fraction went on so the overground total production was 50 per cent higher than in the former year (Table 7). Also here correlation was observed between the maxima of the underground organic matter (0—20 cm) and maxima of precipitation (Fig. 2., Table 7).

Molinio-Salicetum rosmarinifoliae Soó 33/57

On the Bugac pasture, as in the sandy grassland between the Danube and Tisza in general, this association occurs on the lowest sites between the hills. Formerly on these sandy meadow soils lived the association *Schoenetum nigricantis* (ALL. 22) W. KOCH 26. Due to inland drainage water table dropped the soil dried out and the vegetation in consequence of pasturing and trodding became a *Molinio-Salicetum rosmarinifoliae* consisting only few species. The analysis of three years bio-climate measurements could not detect differences (either in daylight or at night) great enough

Table 7. Seasonal dynamics of phytomass production in *Lolio-Potentilletum anserinae festucetosum pseudovinae*
Overground phytomass g/m²

Date	Monocotyl.	Dicotyl.	Phanerogam. total	Moss-lichen	Living total	dead	Total
07.04.77.	20.1	12.0	32.1	1.1	33.2	59.4	92.6
05.05.	42.7	29.9	72.6	—	72.6	23.9	96.5
28.07.	59.5	48.9	108.4	—	108.4	61.9	170.3
23.09.	45.2	54.1	99.3	0.4	99.7	97.4	197.1
27.10.	33.3	25.6	58.9	—	58.9	128.5	187.5
21.11.	28.9	5.2	34.1	—	34.1	102.2	136.3
21.04.78.	28.1	14.1	42.2	—	42.2	164.1	206.3
17.05.	80.7	21.1	101.8	0.4	102.2	187.1	289.3
10.07.	82.6	58.9	141.5	6.3	147.8	252.2	400.0
13.10.	23.9	37.9	61.8	—	61.8	176.3	238.1
15.11.	27.0	8.9	35.9	—	35.9	172.6	208.5
16.02.79.	38.1	6.3	44.4	0.4	44.8	237.4	282.2
23.03.	46.7	5.6	52.3	—	52.3	255.6	307.9
27.04.	43.7	14.8	58.5	—	58.5	174.8	233.3
18.05.	95.2	33.7	128.9	1.9	130.8	81.4	214.9
26.06.	191.9	72.2	264.1	—	264.1	181.5	445.6
15.09.	183.4	96.3	279.7	8.1	287.8	355.6	643.4
18.10.	91.8	22.9	121.0	—	121.0	153.0	274.0

Underground phytomass g/m²

Date	0—5 cm	5—10 cm	10—20 cm	Total
07.04.77.	830	560	106	1550
05.05.	1980	540	350	2870
23.09.	1080	340	150	1570
27.10.	3560	420	160	4140
21.11.	1900	470	420	2790
23.03.79.	2690	230	190	3110
27.04.	1450	460	250	2160
18.05.	2680	340	340	3360
26.06.	1950	490	280	2720
18.10.	1580	700	640	2920

Table 8. Dynamics of productivity the stand g/m² day

Date						
77.		07.04-05.05.	05.05-28.07.	28.07-23.09.	23.09-27.10.	27.10-21.11
		1.45	0.43	-0.16	-1.19	-1.00
78.			21.04-17.05.	17.05-10.07.	10.07-13.10.	13.10-15.11.
			2.29	0.74	-0.84	-0.79
79.	16.02-23.03.	23.03-27.04.	27.04-18.05.	18.05-26.06.	26.06-15.09.	15.09-18.10.
	0.23	0.17	3.35	3.47	0.20	-4.80

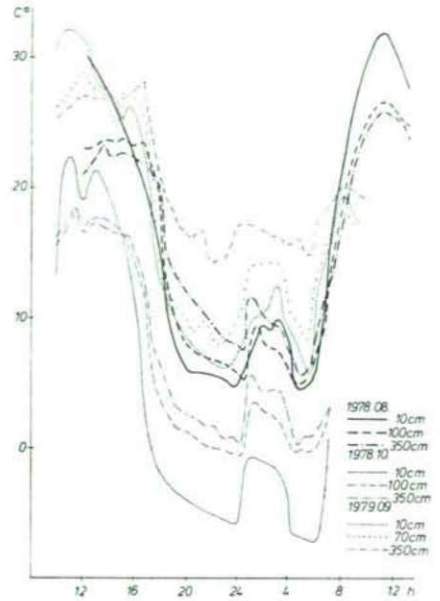


Fig. 7. Dynamics of temperature in *Molinio-Salicetum rosmarinifoliae*.

Table 9. Dynamics of productivity of phytomass (g/m²) in *Molinio-Salicetum rosmarinifoliae*

Date	Mono-cotyl.	Dicotyl.	Phanero-gam. total	Moss-lichen	Living total	Dead	Total
07.04.77.	57.1	15.3	72.4	—	72.4	163.7	236.1
05.05.	71.5	22.9	94.4	2.7	97.1	159.7	256.8
28.07.	37.4	33.1	70.5	11.4	81.9	256.3	338.2
23.09.	61.6	13.6	75.2	1.4	76.6	240.7	317.3
27.10.	52.6	15.2	67.8	5.6	73.4	313.3	386.7
21.11.	14.5	6.3	20.8	11.5	32.3	197.8	230.1
21.04.78.	35.9	7.0	42.9	0.4	43.3	168.1	211.4
17.05.	93.6	79.4	173.0	—	173.0	345.8	518.8
10.07.	142.2	88.7	230.9	10.6	241.5	318.7	560.2
13.10.	67.8	15.2	83.0	4.8	87.8	307.0	394.8
15.11.	29.3	2.6	31.9	0.7	32.6	267.0	299.6
16.02.79.	20.0	2.6	22.6	1.3	23.9	459.6	483.5
23.03.	23.3	5.6	28.9	2.2	31.1	408.9	440.0
27.04.	58.5	29.2	88.7	1.5	89.2	558.1	647.3
18.05.	74.8	41.5	116.3	4.1	120.4	264.4	384.8
26.06.	166.3	44.1	210.4	—	210.4	342.2	552.6
15.09.	221.5	58.9	280.4	3.1	283.5	511.6	795.1
18.10.	102.6	11.1	113.7	—	113.7	662.2	775.9

Underground phytomass g/m²

Date	0—5 cm	5—10 cm	10—20 cm	Total
07.04.77.	2790	300	190	3280
05.05.	2480	410	350	3240
23.09.	2720	820	220	3760
27.10.	2630	590	920	4140
21.11.	2510	900	560	3970
23.03.79.	1320	400	190	1910
27.04.	2970	440	380	3790
18.05.	3250	530	360	4140
26.06.	2260	970	500	3730
18.10.	2050	420	230	2700

to be able to determinate the differences in species composition comparing with the most extereme ecological conditions of *Festucetum vaginatae*. In the *Molinio-Salicetum* stand stood the bio-klimate station number 1. The dynamics of its temperature is shown in Figure 7. Generally it corresponds to that of the former stand. From sunset to sunrise temperature was also here lower with several grades as on the ridges. Fluctuation of temperature at the soil surface was even lower than in the short grass associations, probably in consequence of the height of the plants. Also higher humidity of the soil and nearness of the water table has a similar effect. Relative humidity of air was also 5—8 per cent higher in these lower sites.

Here was registered the highest phytomass production. In the dry year the maximum of the living matter was in May while dead matter production showed a maximum in summer and an other one in fall (Table 9). In 1978 due to the precipitation maximum in June both fractions culminated in July while in 1979, similarly to the stands with *Cynodon* and *Lolium*, maximum was attained in fall. Underground organic matter production is shown in Figure 8.

Table 10. Dynamics of productivity of the stand g/m² day

Date						
77.		07.04- 05.05. 0.78	05.05- 28.07. -0.28	28.07- 23.09. 0.08	23.09- 27.10. -0.21	27.10- 21.11. -1.38
78.			21.04- 17.05. 5.00	17.05- 10.07. 1.07	10.07- 13.10. -1.55	13.10- 15.11. -1.55
79.	16.02- 23.03. 0.18	23.03- 27.04. 1.68	27.04- 18.05. 1.37	18.05- 26.06. 2.42	26.06- 15.09. 0.86	15.09- 18.10. -4.60

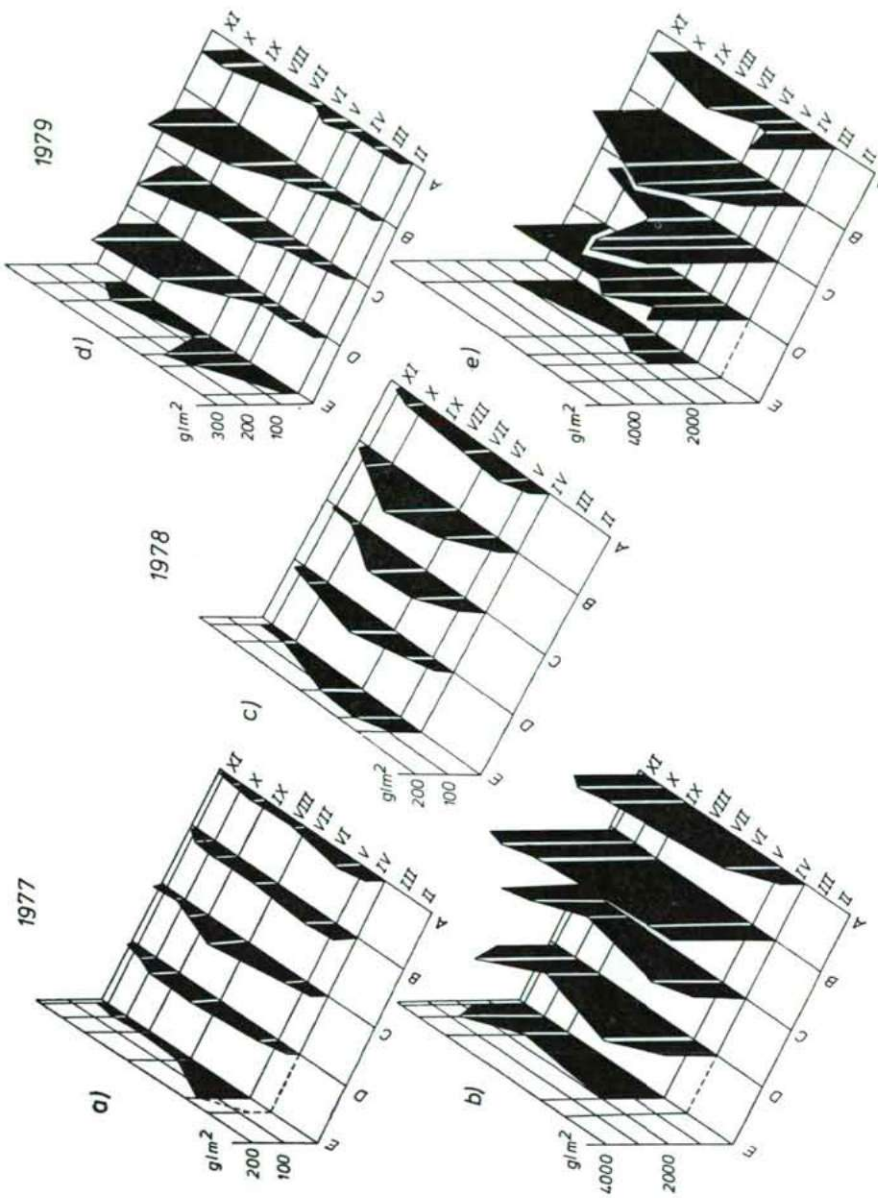


Fig. 8. Seasonal dynamics of overground (a, c, d) and underground (b, e) phytomass in *Festucetum vaginatae* (A), *Molinio-Salicetum rosmarinifoliae* (B), *Potentillo-Festucetum pseudovinae cynodontetosum* (C), *Lilio-Potentilletum anserinae* (D), and *Potentillo-Festucetum pseudovinae brometosum* (E) in the years 1977—79.

References

BODROGKÖZY, GY. and FARKAS, GYÖNGYI (1981): Correlations between vegetation and hydroecology in the sandy grasslands of Kiskúnság National Park — Acta Biol. Szeged. *17*. 33—35

HARGITAI, Z. (1942): Mikroklíma vizsgálatok a nagykőrösi Nagyaerdőben (Microclimate investigations in the Nagyerdő of Nagykőrös). — Acta Geobot. Hung.

KISS, G. (1979): Orthoptera vizsgálatok a Kiskúnsági Nemzeti Parkban pszammofil gyep-ökoszisztémában (Investigations fo Orthopteras in psammophilous grass-ecosystems of Kiskúnság National Park). — Szeged (Thesis).

KOVÁCS-LÁNG, EDIT (1971): Fractional humus investigation of soil under sward communities *(Festucetum vaginatae danubiale, Festucetum wagneri)* growing on sandy sites — Annal. Univ. Sci. Budapest. Sect. Biol. *13*, 163—170.

KOVÁCS-LÁNG, EDIT (1974): A fitomassza produkció és feltételeinek vizsgálata a csévharaszti IBP mintaterületen (Investigation of phytomass production and its conditions in the study area of Csévharaszt). — Budapest (Thesis).

KOVÁCS-LÁNG, EDIT and SZABÓ, MÁRIA (1971): Change of soil humidity and its correlation to phytomass production in sandy meadow association. — Annal. Univ. Sci. Budapest, Sect. Biol. *13*, 115—126.

NAGY, L. (1972): Sugárzás és hőmérsékleti vizsgálatok az újszentmargitai erdőben (Investigation of insolation and temperature in the forest of Újszentmargita). — MTA Biol. Oszt. Közlem. *15*, 51—60.

SIMON, T. és KOVÁCS-LÁNG, EDIT (1972): Produkcióbiológiai vizsgálatok a csévharaszti IBP mintaterületen (Production-biological investigations in the IBP study area at Csévharaszt). — MTA Biol. Oszt. Közlem. *15*, 61—69.

Address of the authors:
L. KÖRMÖCZI
Dr. GY. BODROGKÖZY
Department of Botany, A. J. University,
H-6701 Szeged, P. O Box 428.
Hungary

Acta Biologica Szeged. 27 (1—4), pp. 71—78 (1981)

COMPARATIVE WEED INVESTIGATIONS IN WHEAT AND MAIZE CROPS CULTIVATED TRADITIONALLY AND TREATED WITH WEEDICIDES V. WEED VEGETATION OF WHEAT CROPS BASED ON THE RESULTS OF SURVEY IN 1961—1963 WITH ESPECIAL REGARD TO THE EFFECT OF CROP CHANGE AND PARTIAL MONOCULTURAL CULTIVATION ON THE WEED VEGETATION

RÓZSA FEKETE

Department of Botany, Attila József University, Szeged
(Received June 20, 1980)

Summary

I repeated the weed surveys in wheat crops cultivated traditionally and treated with 2.4-D in 6 places each ot the fields, altogether in 18 units of 12 state farms (resp. cooperative farms) in 1961 and 1963. The results of the surveys can be summarized as dollows:

In comparison with the extensive smallpeasant economy (1950) as a result of modern large-scale agrotechnics the weed cover of wheat crops treated traditionally decreased by more than a half in the last 12—15 years. In 1961 — under crop-change — this decrease was much larger than in 1963 when the effect of partial monocultural cultivation was perceptible on the percentage of weed cover. This percentage is different in every single life forms resp. in their groups depending on the way of cultivation and amount of precipitation; it is on much larger scale at perennials than at annuals. Therefore within the actual much smaller general covering the rates changed for the advantage of annuals especially for thar of group T_4.

The spraying with 2.4-D resulted further 39% decrease in the weed cover of wheat fields, especially annuals were hit.

Overgrowing with weeds is much stronger in monocultural cultivation under traditional as well as chemicalized circumstances. Spraying must be fulfilled earlier because the proper grain weeds (T_2 T_3) damaging first of all the crops in this period are still undeveloped therefore they react more sensibly upon the chemicals so higher weedicid-effect can be rached.

Introduction

Since the first country-wide weed survey (1947—1953) two of the numerous factors have had decisive role: the socialist reorganisation of agriculture resp. the corresponding modern large-scale agrotechnical processes, and the widening application of chemical weedicides. From the beginning of 60-as (between 1961—1965) investigations were carried out — according to these 2 points of view — in the two most important plough-land culture: in wheat and maize under large-scale farming conditions to establish numerically the weedicides modifying effect on the weedvegetation. The reresults of investigations were partly published (FEKETE, 1963, 1964 manuscript, some chapters published in 1973 1974a, b, 1975).

This paper (being one of the chapters of a larger synthetic work still in manuschript) contains the summary of weed surveys in traditionally and with Dikonirt treated wheat crops according to the treatments annually. Namely the data of annual surveys are suitable for the demonstration of the effect of monoculture and

crop change, on the other hand in 1963 — because of the limiting effect of traizine chemicals — the wheat was sown after itself.

Since then naturally these problems resp. their details were studied intensively by others too, moreover in 1969 (1971) the second country-wide weed survey of wheat and maize crops has been realized by the direction of Újvárosi, with the cooperation of more research workers. This asurvey deals only with traditional crops and is limited to the exposition of their weed-relations. Other data explain only weed vegetation of chemicalized wheat crops, se it is almost impossible to compare the data originated from the same place from the two kinds of crops (traditional and treated with weedicides).

Places and methods of investigation

As places of investigation were chosen the same of fields which were particularly elaborated during the first country-wide weed survey.

The places of investigation (the results of the later were summarized and published annually) are the following: 1961: Bábolna, Martonvásár, Mátételke, Debrecen-Nyulas, Karcag and Pánd (surveying places No. 1.), 1963; Fehérgyarmat, Mezőnagymihály, Mezőhék, Enying, Lábod and Kaposvár (surveying places No. 2.). In 1963 more units of the state farms then enumerated were investigated. I surveyed the fields of cooperative farms near the enumerated places too in order to obtain a reliable picture about the weed vegetation of the fields. I compared the results of my surveys with the earlier data of ÚJVÁROSI (1950, 1961) originated from the same places in order to establish the changes in weediness during the last 15 years (with sign 1950, effect of agrotechnic) and the crops treated with chemicals were compared with the actual traditional cultures.

The survey was carried out by the territory-expressive coenological method of BALÁZS mainly (on 8 from the 12 investigated places) on open country adobe and partly on sandy adobe resp. sandy soil. The basic surveys (1950) as well as the 1961—1963 surveys were carried out in June. I made *separated survey series* in all of the places of investigation — regarding as separated places every single unit too — in crops treated traditionally and sprayed with weedicides and this survey-series were considered according to the treatments. In these survey-series the number of surveys is 10 on every investigated place in 1961; every treatment and every survey was made on separated plots. From 1963 the number of surveys is changing depending on the size of the surveyed territory and the composition of weed vegetation: between 300—500 cadastral yoke 10, 500—1000 c. y. 20, over 1000 c. y. 30 and on one plot generally 2 surveys were carried out. Where the weed vegetation wasn't identical enough the number of surveys was doubled. Average value from the series of surveys was taken in every investigated place according to each treatment then the average values were summarized annually (surveying places No. 1. and 2., 1950, 1961, 1963) and in the average of the two years (1950; average of the years 1961—1963).

The whole investigated material was statistically measured: I reckoned t-test between the data from 1947—1951 (with sign 1950) and data from 1961—1963 — annually and summarized too — concerning the whole weed cover, the number of occuring weed species, the individual life forms and their groups, moreover concerning the quantitative relations of weed species occured in large number under traditional circumstances and treated with chemicals including the period of monocultural cultivation.

It is characteristíc of the distribution of precipitation, that during the first country-wide survey (in the years 1947, 1950, 1951) the weather was mainly dry or even droughty with 200—250 mm falling behind the many (40) years average during the breeding season. The survey of 6 places from the 12 investigated fields was carried out during these droughty years that of the other 6 places during 1948 and 1949 which were years with average precipitation. The precipitation relations in 1961 were similar to those of the mentioned dry years, while 1963 was a year with average precipitation and relatively dry spring. In the summarized average of the 12 investigated places in both cases consequently, (in 1947—1951 resp. 1961—1963) the data of yeras with similar relations of precipitation were compared.

Naturally the relations of precipitation on every occasion had a great influence on the appearance of wred vegetation its quantitative and qualitative combination and — to a certain extent — on the effectiveness of weedicide Dikonirt with the agent 2.4-D too.

The preparation of the soil for sowing, the sowing and the following works moreover the dispersion of weedicides on the area treated with chemicals were carried out in optimal or approximately optimal time in proper quality in every farm. The dose of Dikonirt is 1,2—1,3 kg/c.y. The date of sprayings were the middle resp. second part of April in 1961, in 1963 — because ot the late coming of spring — between 5th and 10th May. The spraying was carried out by aeroplane.

Results and discussion

The annual summary of 1961 and 1963 surveys was carried out to see how great differences can be caused in the quantity of weeds and in the mass ratio of every single weed group resp. species by the different conditions of cultivation and different amount of precipitation.

Naturally besides the above mentioned other factors also took part in the rise of these great differences. So for example the effect of premanent cold (−28−29 °C) at the end of February 1963 was very disadvantageous and what's more in some places Italian wheats were cultivated being especially sensitive to cold. As a result of these in 1963 the wheat crops were everywhere thinner and so much more weedy than for example in 1961. On the other hand summing up the results of the two years — the quantitative differences of weed vegetation formed by the mentioned effects partly are compensated, at the same time the data become more reliable and more suitable for generalization. Actually the summarized average of the two years (1961—1963) shows the rate of changes in weed vegetation of wheat crops partly under traditional and partly under chemicalized circumstances during the last 12—15 years passed since the first country-wide survey. According to these results the data of the 30 most frequent weed species were listed in the suitable columns of Table 1. and 2. At the bottom of the Tables are given the total weed cover, the number of weed species and the value of S.D. The distribution of weed vegetation according to life forms — in the same grouping — is shown by Figures 1, and 2.

1. The effect of large-scale agrotechnics on the formation of weed vegetation in wheat crops

From the data of Table 1. occures that in 1961 on the surveying places No. 1. — under crop change — the weed cover has decreased with 60% as compared to that of 1950. In 1963 on the surveying places No. 2. in partial monocultural cultivation the overgrowing with weeds was much more intensive and the degree of decrease is only 50%. Summaryzing the data from the surveying places No. 1. and 2. the weed cover of wheat crops has reduced to one half as a result of the application of modern large-scale agrotechnics (in Table 1. the surveying places No. 1. and 2. columns of 1950 and 1961—1963).

On the other hand, the number of species has slightly increased: in the dry year of 1961 moderately but in the wet year of 1963 considerably. Summaryzing the results of surveying places No. 1. and No. 2. the increase in number of species wasn't considerable.

The changes taken place in the mass-weedingess of wheat crops were totally verified by mathematical statistical analyzis.

Figure 1. demonstrates the main groups of weed vegetation of wheat crops according to their life forms in each year and the summarized average of the two years; so the degree of change at the two most important life forms resp. at their groups can be established. Comparising the data of 1961 and 1963 can be estimated the effect of

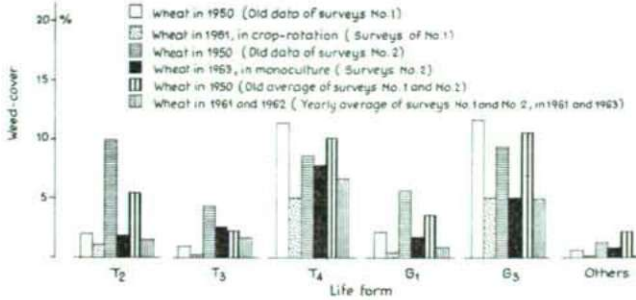


Fig. 1. Effect of large-scale agrotechnics on the formation of weed vegetation of wheat crops according to life forms.

crop change and partial monocultural cultivation on the weed vegetation too. Obviously the degree of decrease is on much larger scale in crop change than in partial monocultural cultivation. In partial monoculture the almost unchanged amount of late summer annuals (T_4) is most conspicuous compared with that of 1950, but the species belonging to the group T_3 occur with grester cover than in 1961. So as compared to the 60—70% decrease of other weed-groups in the latter case only moderate reduction appeared. As a result of this, at present the cover is much smaller and the rates shifted to the advantage of annuals, within them to that of the late summer annuals.

Mathematical statistical analysis shows 70—90% significant differences in the cover changes of every single life froms resp. theirgroups in each year resp. in the summary of the two years; it marks occasional differences as well, and 30—80% value of S.D. for the species belonging to every single group as compared with the data of 1950.

Investigating into the quantitative distribution of weed species occuring most frequently in wheat crops can be established a significant decrease during the last 12—15 years at the majority of species. In the same time multiplication is demonstrable at some species first of all at annuals for example in the case of *Anthemis arvensis, Matricaria inodora, Apera spica-venti, Avena fatua,* etc. It must be emphasized that their multiplication was perceptible only in that plots where crop change didn't happen and wheat was followed by wheat possibly earlier also wheat was sown. This calls the attention to the fact that we have to take into account the multiplication of the mentioned species or that of other species too in case of the increased expansion of monocultural cultivation. Their multiplication in monoculture can be explaned on the basis of weed coenological and other knowledges. Present investigations carried out between 1963—1965 verify this fact having been established by the data of the second country-wide weed survey (ÚJVÁROSI, 1973) too.

2. The effect of spraying with Dikonirt on the formation of weed vegetation of whest crops

The use of Dikonirt wasn't wide-spread in the early 60-s so in order to reduce the sources of error the weed vegetation of wheat crops treated with Dikonirt will be compared only with supposingly untreated crops. Places of investigation were as follows: in 1961 Bábolna, Martonvásár, Mátételke, Debrecen (surveying places No. 1);

Table 1. Percental cover-values of more frequent weed species of wheat crops on the basis of 1961 and 1963 surveys. compared with the data of the first country-wide survey (1947—1951)

Treatment:	Traditional					
Place of surveys:	Surveying places No. 1.		Sureveying places No. 2.		Average of surveying places No. 1. and 2.	
Time of surveys:	1950	1961	1950	1963	1950	1961—1963
Equisetum arvense	—	—	3.618	0.689	1.644	0.413
Consolida regalis	0.780	0.050	1.398	0.222	1.061	0.153
C. orientalis	0.042	0.018	0.686	0.041	0.335	0.032
Rubus caesius	1.598	0.737	0.700	0.919	1.189	0.860
Vicia hirsuta	0.002	0.003	1.936	0.080	0.881	0.049
V. grandiflora	0.020	0.018	0.836	0.012	0.385	0.015
Lathyrus tuberosus	0.130	0.192	0.862	0.269	0.463	0.238
Convolvulus arvensis	5.812	2.722	5.862	2.579	5.848	2.551
Ajuga chamaepitys	0.828	0.200	0.002	0.242	0.453	0.225
Stachys annua	2.028	1.170	0.484	0.926	1.326	1.157
Papaver rhoeas	0.185	0.157	0.382	0.022	0.275	0.076
Fumaria schleicheri	0.030	0.003	0.012	0.033	0.022	0.021
Sinapis arvensis	0.370	0.272	1.012	0.769	0.662	0.570
Diplotaxis muralis	0.698	0.048	—	0.037	0.381	0.041
Raphanus raphanistrum	0.300	0.003	0.012	0.517	0.078	0.311
Lepidium draba	1.407	0.635	1.168	0.138	1.298	0.337
Ambrosia elatior	—	—	2.026	2.141	1.013	1.070
Matricaria inodora	0.013	0.007	0.014	0.492	0.013	0.298
Cirsium arvense	1.785	0.780	1.142	1.453	1.500	1.184
Centaurea cyanus	0.462	0.530	2.400	0.695	1.343	0.629
Scleranthus annus	—	0.002	2.194	0.708	0.997	0.425
Chenopodium polyspermum	—	—	0.014	0.492	0.006	0.295
C. album	1.303	0.427	0.924	0.400	1.131	0.424
Polygonum lapathifolium	0.340	0.050	0.082	0.139	0.223	0.103
P. aviculare	0.622	0.130	1.336	0.330	0.946	0.252
Bilderdykia convolvulus	1.675	0.867	1.572	0.739	1.628	0.790
Agropyron repens	1.405	0.017	0.012	0.168	0.772	0.107
Echinocholoa crus-galli	0.010	0.243	0.418	0.379	0.194	0.325
Setaria glauca	0.402	0.525	0.308	0.073	0.359	0.254
S. viridis	1.067	0.115	0.520	0.173	0.776	0.150
Total weed cover (%)	28.245	11.867	38.324	19.260	32.830	16.300
Number of weed species:	90	99	116	136	142	154
S. D. concerning the total weed cover:		99%		99%		differs
concerning the number of all weed species:		70%		70%		60%
S. D. between the surveys of 1961 and 1963:				95% 20%		

in 1963 Fehérgyarmat—Csholc, Mezőnagymihály, Mezőhék, Lábod—Nagybaráti and Lábod—Nagykorpád (surveying places No. 2). Table 2. contains the average cover values of frequent weed species occured in wheat crops treated traditionally as well as sprayed with Dikonirt in the mentioned farms according to each year and summarizing the data fo the two years. Table 2. shows the distribution of weed vegetation according to life forms.

According to the data of Table 2. further remarkable decrease of weed cover has taken place in wehat crops treated with Dikonirt under the influence of weedicide (Table 2). At the same time it is shown that in 1961 traditional wheat crops cultivated in crop change were more free from weed than in 1963 the wheat crops cultivated in partial monoculture and trated with Dikonirt.

Table 2. Percental cover values of more frequent weed species of wheat crops treated with Dikonirt (2.4-D) according to the surveys in 1961 and 1963 compared with the data of traditional cultures of the same places

Place of investigations	Surveying places No. 1.		Surveying places No. 2.		Average of surveying No. 1. and 2.	
Year of investigation:	1961		1963		1961—1963	
Treatment:	Traditional	With Dikonirt	Traditional	With Dikonirt	Traditional	With Dikonirt
Equisetum arvense			1.238	0.940	0.619	0.470
Consolida regalis	0.075	0.025	0.146	0.028	0.110	0.026
C. orientalis	0.001		0.074	0.006	0.037	0.003
Rubus caesius	0.452	0.160	0.568	0.220	0.480	0.190
Vicia hirsuta	0.004	0.005	0.140	0.080	0.072	0.043
V. gradiflora			0.020	0.002	0.010	0.001
Lathyrus tuberosus	0.208	0.030	0.104	0.078	0.156	0.054
Convolvulus arvensis	1.894	1.747	2.636	2.610	2.265	2.178
Ajuga chamaepitys	0.159	0.120	0.238	0.004	0.198	0.062
Stachys annua	1.954	0.769	1.300	0.264	1.627	0.517
Papaver rhoeas	0.332	0.047	0.028	0.034	0.180	0.041
Fumaria schleicheri	0.008	0.350	0.056	1.272	0.032	0.811
Sinapis arvensis	0.207	0.102	1.342	0.044	0.675	0.073
Diplotaxis muralis	0.033	0.016	0.030	0.008	0.031	0.012
Raephanus raphanistrum	0.001		0.922	0.006	0.461	0.003
Lepidium draba	0.232	0.075	0.248	0.002	0.240	0.038
Ambrosia elatior			1.618	1.124	0.809	0.562
Matricaria inodora	0.003	0.015	0.418	0.124	0.211	0.069
Cirsium arvense	0.966	0.756	0.798	0.664	0.882	0.710
Centaurea cyanus	0.346	0.025	0.936	0.518	0.641	0.271
Seleranthus annuus	0.006		1.250	0.734	0.628	0.367
Chenopodium polyspermum			0.488	0.020	0.244	0.010
C. album	0.293	0.397	0.612	0.598	0.453	0.498
Polygonum lapathifolium	0.161	0.025	0.098	0.098	0.129	0.061
P. aviculare	0.280	0.162	0.532	0.268	0.406	0.215
Bilderdykia convolvulus	0.904	1.018	0.896	0.468	0.900	0.743
Agropyron repens	0.006	0.022	0.212	0.566	0.109	0.294
Echinochloa crus-galli	0.084	0.082	0.472	0.430	0.278	0.256
Setaria glauca	0.859	0.305	0.126	0.026	0.492	0.165
S. viridis	0.298	0.146	0.264	0.580	0.281	0.363
Total weed cover (%)	11.656	7.394	21.292	14.140	16.517	10.767
Number of all weed species:	84	70	102	97	123	114
S. D. concerning the total weed cover:		99%		Differs		differs
concerning the number of all weed species:		70%		60%		60%
S. D. between the surveys of 1961 and 1963;				98%		95%
				20%		10%

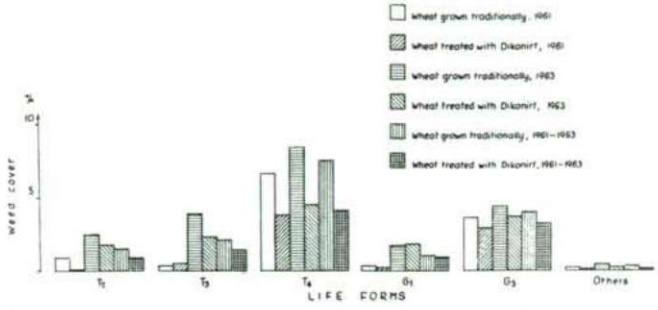


Fig. 2. Effect of Dikonirt-spraying on the formation of weed vegetation of wheat crops according to life forms.

Figure 2. demonstrates the effect of Dikonirt on every single weed group showing that it defeats first of all annuals. In connection with this it must be mentioned that in 1961 because of the early sprayings the damage of proper grain weeds (T_2) was much greater than in 1963 when because of the late coming of spring the time of spraying was postponed. In the latter case by thet time of spraying the weeds of this group and part by weeds belonging to the group T_3 were in shooting state so they weren't so senditive to the chemicals.

Investigating the quantity of every single species it can be established that Dikonirt caused a significant decrease at the majority of species, at the same time *Fumaria sleicheri, Agropyron repens* did it in smaller degree (Table 2). In monocultural plots like in traditionals — besides the mentioned other species increase was experienced. Practically all the problems of the 70-s occured at this time though not so sharply expressed (BEA, 1973; CSANÁDY, 1972; KOROKNAI, 1976; MADARÁSZ, 1974; 1976).

References

BEA J. (1975): Őszi kalászosok vegyszeres gyomirtásának tapasztalatai a bonyhádi járásban (Observations of weed control in winter cereals in Bonyhád district). — Növényvéd. *9*, 418—419.

CSANÁDY A. (1972): A nagy széltippan *Apera spica-venti* (L.) B. B. Somogy-megyében (*Apera spica venti* (L.). P. B. in Somogy county). — Növényvéd. *8*, 218—219.

FEKETE R. (1963): Változások a szántóföldi gyomnövényzetben (Changes in the weed vegetation on cultivated land). — MTA Agrártud. Oszt. Közl. *22*, 377—393.

FEKETE R. (1964): Comparative weed-investigations in wheat and maise crops cultivated traditionally and treated with chemical herbicides (Manuscript, transcribed in the form of a doctoral dissertation 1967, submission and defence 1972; some chapters were published 1973—75).

FEKETE, R. (1973): Comparative weed investigations in wheat and maize crops cultivated traditionally and treated with weedicides. I. Changes in the weed vegetation of wheat crops. — Acta Biol. Szeged., *19*, 3—11.

HUNYADI K. és REISINGER P. (1972): Herbicidek szántóföldi alkalmazása során jelentkező gyomproblémák vizsgálata (A study of weed problems arising with the field application of herbicides). — Keszthelyi Mezőgazdaságtud. Kar Közl. (University of Agric. Sci. Keszthely) *14*, 3—31

KÁLDY J. (1974): A nagy széltippan és a sovány perje elterjedése Vas megye őszi gabonáiban és az ellenük való védekezés lehetőségei (Distribution of *Apera spica—venti* and *Poa trivalis* in the winter cereals of the department Vas and possibilites of their control). — Növényvéd. *10*, 555—557.

KOROKNAI B. (1972): Őszivetésű gabonafélék vegyszeres gyomirtásának tpasztalatai Veszprém megyében. (Observations of weed control in winter cereals in Veszprém country). — Növényvéd. *12*, 451—456.

KOROKNAI B. (1975): A nagy széltippan *(Apera spica-venti)*, a hélazab *(Avena fatua)* és a fenyércirok *(Sorgum halepense)* elterjedésének vizsgálata 1975-ben (Researches made into the spreading of *Apera spica-venti, Avena fatua* and *Sorgum halepense* in 1975). — Növényvéd. *12*, 451—456.

MADARÁSZ J. (1974): Avena fatua (gélzab) fertőzöttség Borsod-Abaúj-Zemplén megyében és az ellene való védekezési kísérletek eredményei. (Infestation of Avena fatua in the department Borsod-Abaúj-Zemplén and results of weed control experiments). — Növényvéd. *10*, 362—364.

MADARÁSZ J. (1976): *Avena fatua* (hélazab) elterjedését elősegítő tényezők és az ellene való védekezés lehetőségei (Factors promoting the spreading of *Avena fatua* and possibilities of control). — Növényvéd. *12*, 367—370.

MTA Talajtani és Agrokémiai Kutató Intézet Talajtani Osztály munkái (talajvizsgálati jegyzőkönyvek és átnézetes talajismereti térképek, 1941—1950, kiadatlan). (Works in Agrochemical Research Institute, Department of Soil Science, Acad. Sci. Hung. Reports of soil experiments and soil maps, 1941—1950, unpublished).

SVÁB J. (1967): Biometriai módszerek a mezőgazdasági kutatásban. (Biometric methods in the agricultural research). — Mezőgazdasági Kiadó, Budapest.

SWEIGERT A. (1977): Nagy széltippan [Apera spica-venti (L) P. B.] fertőzöttség Somogy megyében és az ellene való védekezés. (Fertility of Apera spica-venti in Somogy county and methods of the control). — Növényvéd. *13*, 68—70.

UBRIZSY G. (1958): Gönológiai kutatások agrárterületek gyomtársulásain, különös tekintettel a vegyszeres gyomirtás flóraátalakító hatására. (Ceonological investigations of the weed coenoses of agricultural areas, with particular regard to the flora-transformative effects of chemical weed-killers). — MTA Biol. Csop. Közl. *2*, 65—78.

UBRIZSY G. (1971): A vegyszeres gyomirtással kapcsolatos biológiai alapkutatások jelentősége. (Importance of biological researches connected with the chemical weed-control). Kísérletügyi Közl. MÉM 64/C, 1—3, 93—111.

UJVÁROSI M. (1950): Hol milyen gyomok ellen védekezzünk? (Wich weeds to protect against where?). Debreceni Mezőgazd. Kis. Int. Évk. *1*, 27—105.

ÚJVÁROSI M. (1961): A búzavetések gyomnövényzete. Búzatermesztési kísérletek 1952—1956. (Weeds in wheat crops. Experiments in wheat-growing, 1952—1956). — Akad. Kiadó, Budapest.

ÚJVÁROSI M. (1973): Gyomnövények, Gyomirtás I, II. (Weeds and their elimination I, II) Mezőgazd. Kiadó Budapest.

Address of the author:
Dr. RÓZSA FEKETE
Department of Botany, A. J. University
H-6701 Szeged, P. O. Box 428, Hungary

Acta Biologica Szeged. 27 (1—4), pp. 79—88 (1981)

COMPARATIVE WEED INVESTIGATIONS IN WHEAT AND MAIZE CROPS CULTIVATED TRADITIONALLY AND TREATED WITH WEEDICIDES
VI. THE FORMATION OF WEED VEGETATION OF WHEAT CROPS CULTIVATED IN PARTIAL MONOCULTURE UNDER TRADITIONAL AND CHEMICALIZED CIRCUMSTANCES

RÓZSA FEKETE

Department of Botany, Attila József University, Szeged
(Received June 20, 1980)

Summary

Between 1963 and 1965 I made weed investigations in wheat crops cultivated traditionally, sprayed with different phenoxy-acetic acid-derivatives (2.4-D; 2.4-D amin; MCPA amin), moreovein wheat crops under the after-effect of Simazin resp. Atrazin, in 5 units of 3 state farms (Mezőnagyr mihály, Enying, Lábod). The green crop in the majority of the surveyed areas was wheat. In 2 of the 3 surveyed farms weed survey took place during the first country-wide survey (1950) too.

We can establish from the results of the investigations as follows:

As a result of application of modern large-scale agrotechnics the weed cover has remarkably decreased in wheat crops cultivated traditionally during the last 12—15 years compared to that of 1950. The decrease is on a larger scale at perennials than at annuals.

In monoculture the overgrowing with weeds of wheat crops — under traditional as well as chemicalized circumstances — is stronger than in crop change. In monoculture annuals have multiplied in greater amount altough occasionally perennials did it too.

On the areas standing under after-effect of Simazin resp. Atrazin we can count with harmful aftermaths even in the 3rd year after the spray. The crop damage caused by the after-effect resulted 20—60%. Overgrowing with weeds as compared to the control and this resulted in the harvest as well.

In the 4nd, year after the spray no damage appeared in wheat crops; its harvest, weed cover and the number of species corresponded to those of wheat crops cultivated traditionally. Because of the long-lasting persistence of Simazin resp. Atrazin in dose 5—7 kg/c.y. wheat can be cultivated safely only in the 4nd year after the spray.

Introduction

The structural changes taken place in Hungarian agriculture resulted in the use of modern large-scale agrotechnical processes including the chemical processing of agriculture among others the use of different herbicides. Of the latter from 1959 and the early 60-s chlor-amino-triazines have been used because of their long-lasting persistence the maize had to be cultivated for some years after itself. As a result of this a part of wheat crops was cultivated in monoculture in the majority of the farms. The industrial systems of production expanding quickly since the middle of 70-s have also resulted the change of crop structure and increase of *monocultural cultivation.*

Naturally this facts in all effected in weed veaetation's quantitative and species-composition. So their investigation possibly in the same areas within several years was obvious. It was necessary since at the beginning of the investigation we haven't data concerning these. Since that time a number of papers were published concerning

the details of this subject as well as the effect of large-scale agrotechnics and herbicides but there is a shortage in data concerning the weed vegetation of wheat crops cultivated in monoculture furthermore that of wheat crops in areas treated with Simazin resp. Atrazin for maize in the preceding year — as far as home-relations — are concerned. Namely during the last 15 years none of the papers concerning weed vegetation of wheat crops examined it in monocultures; the wheat crops sown in areas treated with Simazin resp. Atrazin in the preceding year were discussed only from the view point of damage of cultivated plant (I'só, 1962, 1966) but data concerning their weed vegetation weren't published.

Investigated places and methods

Weed investigations were carried out in Mezőnagymihály, Enying and Lábod between 1963 and 1965 in wheat crops cultivated traditionally, sprayed with Dikonirt (2,4-D), Dikamin (2.4-D amin), Dikotex 40 EC (MCPA amin) and in *wheat crops* standing under after-effect of Simazin resp. Atrazin. In the wheat crops cultivated traditionally as well as in crops sprayed with different phenoxy — acetic acid-derivatives — according to the possibilities — surveys in 2 and 3 years old monocultures as well as in monocultures under crop change were made so some of the areas were partly or totally identical during the time of investigation (between 1963 and 1965), (for example the plot standing under after-effect of Atrazin in Enying). In 2 of the 3 surveyed farms in Mezőnagymihály and Lábod weed survey happened during the first country-wide survey too (Újvárosi, 1950).

The basic surveys as well as the surveys between 1963 and 1965 were made in June with the area-expressive coenological method of Balázs on soils field-adobe (Mezőnagymihály—Klementina; Enying), clayey-adobe (Mezőnagymihály—Baglyas), adobe resp. partly sandy adobe (Lábod—Nagybaráti, Lábod—Nagykorpád). In every investigated places and in the units of every single state fram I made separate survey-series in crops cultivated traditionally and sprayed with different herbicides, and this survey-series were analyzed annually everywhere according to every single treatment. Concerning the number of surveys, their distribution in every single plot is reported in the publication No. V. From the average of survey-series of these places the first 15 weed species occuring in the greatest amount with their percental cover-calues in the Tables 1—3 are indicated. The tab bles — according to every single treatment annually — contain the number of weed-species, the total cover of weeds and the results of mathematical statistical analyzis. The main groups of the distribution of weed vegetation according to their life forma are shown in the Figure 1—3.

As far as precipitation is concerned the weather was very dry in the investigated places in 1950. 1963 and 1964 were years with average amount of precipitation but 1965 vas a very wet year with 250—500 mm exceeding the average of 40 years. In 1963 the time of spray was the first week of Mai because of the late spring still in 1964 and 1965 it was the middle of April. The dose of herbicides was: Dikonirt: 1.3 kg/c.y.; Dikamin: 2 1; Dikotex: 40; EC: 2.2 kg/c.y.

The areas of wheat crops sown in plots treated with Simazin resp. Atrazin for maize in the őrecedomg years were sprayed with 7 kg/c.y. Simazin in Mezőnagymihály in spring of 1961. In Enying on one part of the nivestigated plots in autumn 1960, on the other part in spring of 1961 5—5 kg/c.y. Simazin resp. Atrazin were applicated, in addition in 1961 and 1962 — when maize was cultivated on these areas — 1.1 kg—c.y. Dikonirt. I. investigated the wheat crops sown in these areas during 3 subsequent years. The wheats standing under after-effect of Simazin resp. Atrazin were treated with Dikonirt only in Mezőnagymihály. In 1964 the latter areas were not sprayed with weedicides but in 1965 Dikotex 40 EC was applicated.

Results and discussion

1. Weed vegetation of wheat crops of State Farm at Mezőnagymihály

Weed investigations were carried out in the next units of the farm: Bagjas and Klementina in wheat crop cultivated traditionally sprayed with Dikonirt Dikamin Dikotex 40 EC, and in wheat crops standing under aftereffect of Simazin. The surveys

of wheat crops cultivated traditionally in 1963 were made in the plots of cooperative farms being near Mezőkövesd—Mezőkeresztes the others in 2 further units of the state farm.

On the area of wheat plots treated with Dikonirt in 1963 wheat was cultivated in the previous year too. The area of the crop trested with Dikotex 40 in 1965 also was also identical with the wheat sprayed with Dikamin in the previous year. In the plots treated with Simazin for maize during the previous years also wheat was cultivated in 2 subsequent years.

a) Weed-vegetation of wheat cultivated traditionally:

At the time of 1963 resp. 1965 surveys its weed cover was considerably smaller as compared to that of 1950, although weed covered still great areas. The changes of weed vegetation are testified by significance investigations too (Table 1). The distribution of weed veaetation according to life forms and the changes are shown by the Figure 1.

The considerable decrease of group T_2 is obvious on the figure at the same time T_3 but expecially T_4 have multiplicated so that the total cover of therophyta life form didn't change considerably compared to that of 1950. On the contrary the quantity of perennial radiciform couch-grasses (G_3) has considerably decreased. The changes were verified by mathematical statistical analyzis because geophyta life form including the cover of group G_3 differs significantly from that of 1950, but at the therophyta life form resp. its certain groups the S.D. values differed 40—90% in positive or negative direction.

The quantitative changes of most frequent weed species are shown in Table 1. Obviously from among annuals the typical eared weeds were totally repressed as well as the most harmful perennials but at the same time among annuals and perennials we can find some species multiplaying for example Sinapis, *Stachys, Bilderdykia* and *Rubus*.

b) Weed vegetation of wheat crops treated with different phenoxy-aceticacid-derivatives

Table 1. shows that under different cultivation-circumstances different weedicide effect is produced even by homotypical chemicals. As it has been mentioned the green crop of crops sprayed with Dikonirt and Dikotex EC 40 was wheat, so in these plots the overgrowing with weeds was much stronger and the effect of herbicide couldn't be felt so much as in changed crops treated with Dikamin. The effect of 3 weedicides on every single life forms and their groups is shown also by Figure 1. (The data of wheat crops treated with Dikotex 40 EC by mistake are indicated as treated with Dikonirt). As it is visible Dikamin reduced to nothing all weed groups characteristic for wheat crops, on the other hand the other 2 herbicides destroyed first of all the weeds of group T_2 and T_3 and they had less effect on the others. In wheat treated with Dikonirt the greater amount of group T_3 was caused by the multiplication of *Fumaria*. Table 1. shows the effect of investigated herbicides on every single weed species.

c) Weed vegetation of wheat crops standing under aftereffect of Simazin:

The state farm cultivated wheat on the investigated plots in the 3rd and 4nd years after spraying with Simazin. The results of the first year of investigation (1963)

have already been published discribing the damage of crops and as a result of this their considerable overgrowing with weeds (FEKETE 1964 manuscript, published in 1973). In the 4nd year after the spraying (1964) the crop wasn't damaged and its weed cover was only 10% (Table 1).

Table 1. More frequent weed species of wheat crops of Mezőnagymihály State Farm with their cover values in the years 1963—1965

Units:	Field-mean:	Klementina unit:			Bagjas unit:				
Treatments:		Tradi-tional	Dika-min	Tradi-tional	Díko-nirt	Simazin aftereffect in 1961		Dika-min	Diko-tex 40
Time of investigation:	1950	1963	1964	1965	1963	1963	1964	1964	1965
	VI. 14.	VI. 16.	VI. 9.	VI. 29.	VI. 17.	VI. 17.	VI. 8.	VI. 8.	VI. 28.
Rubus caesius	0.63	1.53	0.37	2.37	0.79	3.12	3.12	0.19	0.84
Lathyrus tuberosus	0.94	0.41	0.04	0.02	0.30	2.12	0.92	0.04	0.38
Convolvulus arvensis	12.81	3.15	0.17	4.50	2.85	3.76	1.64	0.07	0.58
Stachys annua	0.08	2.40	—	—	0.12	0.07	0.99	—	1.26
Fumaria scleicheri	—	0.08	—	0.04	3.51	0.27	—	—	0.01
Sinapis arvensis	0.06	3.57	—	3.19	0.16	—	0.03	0.01	0.02
Lepidium draba	4.00	0.22	0.66	0.72	—	—	—	—	—
Thlaspi arvense	2.32	0.09	0.16	0.06	—	—	—	0.15	0.01
Cirsium arvense	0.06	1.62	0.03	2.06	1.26	0.04	0.06	0.31	0.49
Chenopodium album	0.13	0.86	0.03	0.06	0.50	1.62	0.21	0.01	0.01
Anagallis arvensis	—	0.09	—	0.02	0.13	0.69	0.05	0.01	1.01
Polygonum aviculare	0.72	0.35	0.01	—	—	—	0.01	—	0.08
Bilderdykia convolvulus	0.22	1.31	0.01	2.54	—	0.12	0.20	0.01	1.90
Echihochloa crus-gallia	0.10	0.21	0.03	0.02	1.46	16.25	0.32	0.01	0.02
Setaria viridis	0.29	0.17	0.01	0.39	2.30	0.31	0.15	—	0.50
Total weed cover:	29.01	20.20	1.82	18.46	15.75	33.38	10.01	1.66	11.75
Number of weed species:	34	53	13	30	34	36	27	20	38
S. D. concerning the total weed cover:		80%	differs		95%	differs		differs	95%
total number of species:		98%	differs		differs	80%		differs	differs
S. D. concerning the treatments in the units and between units (in the same year)								20% 10%	
S. D. comparison of years:			40% identi-cal				differs differs		40% 10%

For comparison I indicated the results of 1963 weed investigations as well in the Table and Figure; showing that at that time the late summerweeds (T_4) multiplicated in greater amount but in the next year because of the necessary density of crops they were quite repressed. The perennial radiciform couch-grasses (G_3) also covered greater area here than in crops cultivated traditionally and their amount was esetially the same in both years (Fig. 1).

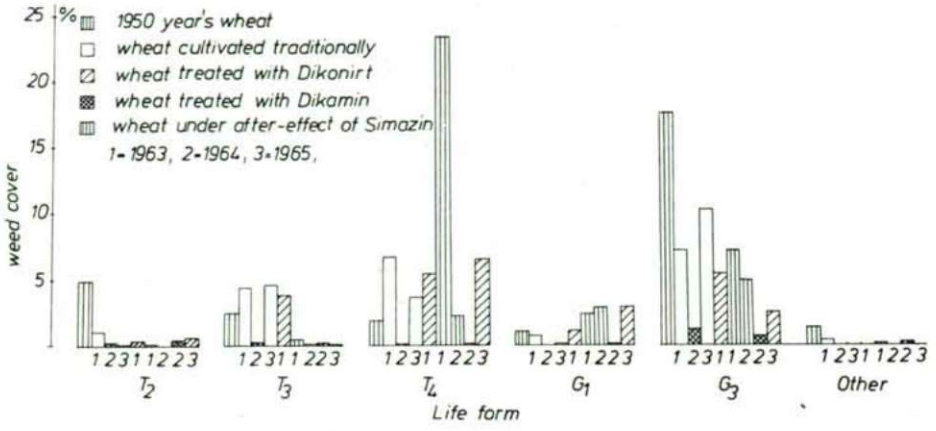


Fig. 1. Distribution of weed vegetation according to life forms in wheat growing traditonally, treated with fenoxiacetic acid derivates and under Simazin post-effect; in the Mezőnagymihály State Farm.

2. Weed vegetation of wheat crops of Enying State Farm

In autumn of 1962 the farm sowed wheat into 2 greater areas standing under after-effect of Simazín resp. Atrazin, in which in 1964, in some plots in 1965 also wheat was cultivated. I had been investigating this plots for 3 years. The doses of weedicides applicated on the areas see in part: "Methods". Surveys were made in untreated wheat crops cultivated in crop change of the local cooperative farm in 1963 and that of the state farm in 1964 for the sake of comparison of their weed vegetation.

a) Weed vegetation of wheat cultivated traditionally:

In 1963 the cooperative farm cultivated italian wheat. This race is much more senssitive to cold so its stand became thinner and got very weedy. Next year the crops had quite low weed cover so comparing the 2 years weed quantities remarkable differences can be spotted (Table 2).

The distribution of weed vegetation according to their life forms is shown in Figure 2.

The mass-occurence of annuals including the late summer species (T_4) and the radiciform perennial couchgrasses (G_3) is characteristic to the weed vegetation of wheats cultivated traditionally in 1963. The perennial couch-grasses (G_1) didn't cover big area, butthey are considerable first of all because of Sorgum halapense which is one of the caranteen-weeds in Hungary. This has been the first data of its occurence on cultivated areas. Next year — because of the sufficient density of crops — all weed groups were limited to small area. In 1963 among annuals Ambrosia elatior occured in great amount, among perennials Rubus caesius and Convolvulus arvensis. In 1964 all species covered much less area (Table 2).

b) Weed vegetation of wheats standing under after-effect of Simazin resp. Atrazin:

Results of the first investigation-year of wheat crops standing under after-effect of Simazin resp. Atrazin have elredy been published (FEKETE, 1964 manuscript, publi-

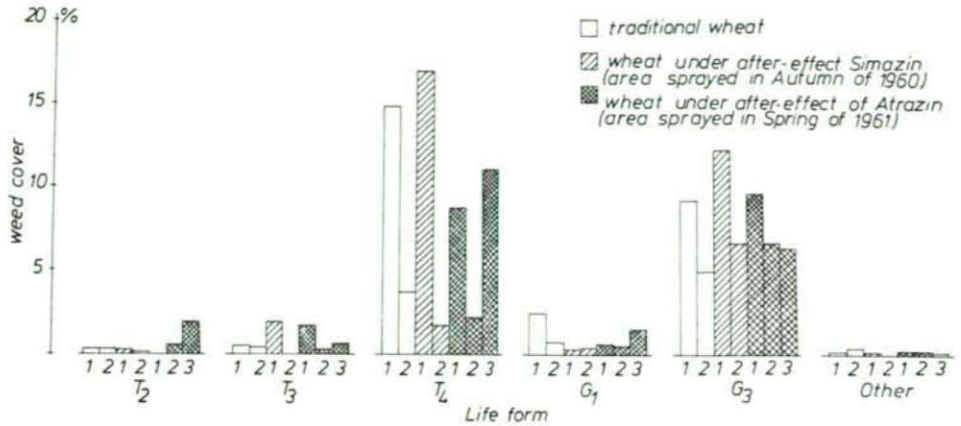


Fig. 2. Distribution of weed vegetation according to life forms in wheat growing traditionally and under Simazin resp. Atrazin post-effect, in the Enying State Farm.

Table 2. More frequent weed species of wheat crops in Enying Statefarm with their cover values in the years 1963—1965

Treatment:	Traditional		After-effect of Simazin Autumn of 1960		After-effect of Atrazin Spring of 1961		Dikotex 40
Time of surveys:	1963	1964	1963	1964	1963	1964	1965
	VI. 26.	VI. 22.	VI. 26.	VI. 22.	VI. 26.	VI. 22.	VI. 24.
Rubus caesius	4.81	2.18	10.31	5.50	6.12	3.94	5.01
Lathyrus tuberosus	1.33	0.11	0.29	0.27	0.01	0.02	1.45
Convolvulus arvensis	3.26	2.61	1.88	1.15	3.51	2.65	1.31
Ajuga chamaepitys	0.99	0.08	0.03	0.01	0.20	0.22	0.01
Stachys annua	1.52	0.81	4.61	0.53	2.43	0.89	3.24
Melampyrum barbatum	0.43	0.06	1.71	—	0.27	0.02	0.08
Papaver rhoeas	0.02	0.07	—	—	—	0.32	1.46
Sinapis arvensis	0.04	0.29	0.12	—	1.41	—	0.44
Ambrosia elatior	9.21	1.26	7.26	0.08	4.01	0.01	3.50
Cirsium arvense	1.06	0.16	0.01	0.01	—	0.08	—
Chenopodium album	0.25	0.19	1.17	0.17	0.39	0.12	0.16
Anagallis arvensis	1.08	0.33	0.06	—	0.25	0.03	1.92
Bilderdykia convolvulus	0.48	0.36	0.09	0.33	0.07	0.32	1.13
Echinochloa crus-galli	0.16	0.08	0.60	0.05	0.01	0.06	0.02
Setaria viridis	0.20	0.21	2.36	0.38	0.81	0.11	0.09
Total weed cover:	27.24	10.12	31.40	8.81	20.62	10.26	21.37
Number of weed species:	36	42	26	22	31	38	39
S. D. concerning the total weed cover:		differs	70%	70%	80%	identical	differs
the number of species:		differs	differs	differs	differs	90%	10%
S. E. in comparison of years:				differs 99%	10% 95% (1963—1965)	98% 40%	differs 80%
S. D. between the identical treatments:		differs differs	95% 50%	30% 90%	95% 50%	30% 90%	

shed in 1973). For the sake of comparison the results of investigations in 1963 are also ndicated in the present paper (Table 2. and Fig. 2). Obviously the plots treated with Simazin in autumn 1960 were much more weedy than the plots treated with Atrazin in spring 1961, in which the crop — in contradiction with those sprayed in autumn of 1960 — has less damage.

Next year (1964) no demage was noticed neither in crops being in the areas treated in autumn 1960, nor in those treated in spring 1961. Their stand closed perfectly with sufficient density and with quite low weed cover which corresponded with the stand of crops cultivated traditionally. In 1965 I investigated only the crops being in the areas sprayed in spring 1961 with Dikotex 40 EC. Because of the monocultural cultivation having lasted for 3 years it was impossible to repress weeds even with herbicides (Table 2, area sprayed in 1961, surveyed in 1965). Mathematical-statistical analyzis gave the results indicated in Table 2. concerning the total weed cover and the number of species on the investigated areas in comparison with crops cultivated traditionally, the plots under after-effect of Simazin resp. Atrazin were comparised with each other and the data of previous year of the same areas.

Comparing the distribution of weed vegetation according to life forms (Fig. 2) it can be established that in the first investigated year the late-summer weeds (T_4) and perennial radiciform couch-grasses (G_3) multiplicated in greater amount especially in plots sprayed in autumn 1960. Next year as a result of weedrepressive effect of wheat all weed groups were repressed back. However in the last investigated year (in 1965) in the crop with rather thin stand in spite of chemical treatment the annuals were in great amount again first of all the late-summer weeds. So in these plots the life form T reached its highest cover value which possibly can be the result of monoculture lasted 3 years. In the plots standing under after-effect of Simazin resp. Atrazin — similarly to the traditional — there were Rubus caesius, *Convolvulus arvensis* and *Ambrosia elatior* in great amount (Table 2).

3. Weed vegetation of wheat crops in Lábod State Farm

Weed investigations were made in Nagybarát and Nagykorpád units of the state farm in wheat crops cultivated traditionally and sprayed with Dikonirt. In the majority of the investigated plots wheat had been cultivated for 2 or 3 years.

a) Weed vegetation fo wheats cultivated traditionally:

In 1950 at the time of the first country-wide survey they were the most weedy wheat crops of the country. By 1963 resp. 1965 large-scale decrease of weed cover had taken place. In spite of 68—70% cover decrease the crops haven't been satisfactorily free of weeds yet (Table 3).

As compared the weed vegetation according to life forms we experience the next (Fig. 3).

During the first country-wide survey in the wheat crops of these areas the annuals (52,98%), from among the perennials the couch-grasses (G_1) have been in enornous amount. According to the 1963 resp. 1965 investigations both life forms were present with 1/3, 1/4 of their former amount in spite of this the cover of annuals can be considered still high, which can be explained possibly with the partial monocultural cultivation of wheat crops. The cover of the 2 important life form (T, G) is shown by Fig. 3, from which the degree of decrease can be established. This changes were verified by mathematical statistical analyzis.

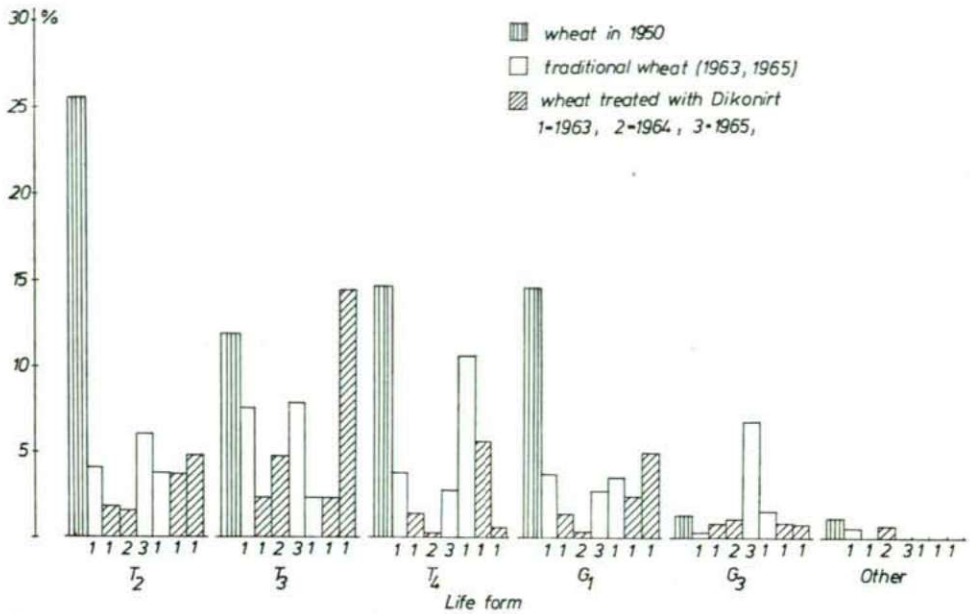


Fig. 3. Distribution of weed vegetation according to life forms in wheat growing traditionally and treated with 2.4-D.

The area-occupation of more frequent weed species is shown in Table 3. — so the changes can also be followed. Like the other investigated places very considerable decrease has taken place at the majority of them, at the same time *Raphanus raphanistrum, Anthemis arvensis, Agropyron repens* occassionally multiplicated, dan by 1965 *Scleranthus annuus* had also reached considerable amount.

b.) Weed vegetation of wheats treated with Dikonirt:

In the whest crops sprayed with Dikonirt as an effect of weedicides 45—50% decrease of weed cover had taken place (In Table 3. wheats treated with Dikonirt in 1963 and 1964 in Nagybarát unit). On the other hand in Nagykorpád unit the decrease is only 30%.

Comparing each life form it can be establish that Dikonirt decreased the total cover of annuals to 1/3 in both years. The effect of herbicide resulted in every group of annuals 55—70% differences in the cover.

On the other hand in Nagykorpád the weeds of T_2 and T_3 groups occure in the same amount as traditionally and late summer weeds shot up after weedicide effect's passing also had heveloped by that time. The damage of more frequent weed species caused by Dikonirt is shown by the suitable colums of Table 3.

The effect of Dikonirt wasn't clear-cut at hardies in soil (G).

The third years wheat monoculture of the state farm in 1963 in worth mentioning, its weed vegetation can be found in Table 3. and Fig. 3. in the last column. Obviously in this areas in spite of spray with Dikonirt weeds covered much greater areas than in traditionally cultivated wheats. Especially the early summer weeds shot up in

spring (T_3, Fig. 3) first of all Viola arvensis occured in greater amount. From among perennial couch-grasses (G_1) the multiplication of *Agropyron repens* calls attention to the draw-backs of monoculture.

According to mathematical statistical analyzis Dikonirt resulted in the weed cover of wheats 95—99% singificant differences at therophyta life form resp. its groups while 50—80% differences at geophyta life form resp. itsgroups as compared with wheat crops cultivated traditionally. According to the number of species the same differences resp. deviations occured.

Table 3. More frequent weed species of wheat crops in Lábod State Farm with their cover values in hte years 1963—1965

Units:	Field-mean:	Nagybarát unit:				Nagykorpád		3 years old mono-culture
Treatments:		Trad.	Diko-nirt	Diko-nirt	Trad.	Trad.	Diko-nirt	Diko-nirt
Time of the investigation:	1950	1963	1963	1964	1965	1963	1963	1963
	VI. 19.	V. 31.	V. 31.	VI. 11.	VI. 22.	VI. 27.	VI. 27.	V. 31.
Equisetum arvense	14.65	3.07	2.50	—	—	3.12	2.20	0.37
Vicia hirsuta	8.37	0.10	—	—	—	0.49	0.04	—
Convolvulus arvensis	1.25	0.31	0.95	1.03	4.27	1.40	0.87	0.70
Raphanus raphanistrum	—	3.76	0.03	—	0.02	—	—	0.07
Viola arvensis	0.97	0.29	0.60	0.12	0.50	0.19	0.22	9.43
Ambrosia elatior	8.81	2.19	0.90	0.08	2.25	6.70	4.72	0.10
Anthemis arvensis	2.66	0.11	0.13	0.48	4.03	0.04	0.20	2.78
Centaurea cyanus	7.94	3.23	1.30	0.06	0.33	1.59	1.26	1.53
Scleranthus annuus	10.97	3.03	1.62	5.26	7.29	1.81	1.93	4.97
Chenopodium album	0.04	0.11	0.06	—	—	1.15	0.05	0.02
Rumex acetosella	0.13	—	—	0.06	2.78	0.01	0.06	
Polygonum aviculare	1.53	1.42	0.04	0.01	0.01	0.19	0.26	0.43
Agropyron repens	0.06	0.99	2.57	1.47	0.32	0.07	0.25	3.69
Apera spica-venti	1.28	0.06	0.17	0.52	1.42	1.26	1.73	0.93
Echnochloa crus-galli	1.37	0.01	0.08	0.02	0.03	0.78	0.26	0.06
Total weed cover %:	69.57	20.52	11.67	10.50	24.10	22.22	15.69	26.53
Number of all weed species:	47	38	23	24	27	32	31	24
S. D. concerning the total weed cover:		differs	95%	98%		differs	95%	differs
the total number of species:		differs	98%	99%		differs	80%	98%
S. D. between the identical treatments:					95% differs		90% 98%	99%
between years concerning the same data:				50% identi-cal	95% differs			differs 99%

References

FEKETE R. (1963): Változások a szántóföldi gyomnövényzetben (Changes in the weed vegetation on cultivated land). MTA Agrártud. Oszt. Közl. *22*, 377—393.

FEKETE, R. (1964): Comparative weed — investigations in wheat and maize crops cultivated traditionally and treated with chemical herbicides (Manuscript, transcribed in the form of a doctoral dissertation 1967, submission and defence 1972; some chapters were published 1973—1975).

FEKETE, R. (1973): Comparative weed investigations in wheat and maize crops cultivated traditionally and treated with weedicides. I. Changes in the weed vegetation of wheat crops. — Acta Biol. Szeged, *19*, 3—11.

I'SÓ K. (1962): Utóhatás-kísérletek őszi búzában klóraminotriazinokkal kezelt kukorica után (After-effect experiments in winter wheat after maize treated with cloro-aminotriazines). — Kukoricaterm. Kísérl. 1958—1960, 348—354.

I'SÓ I. (1966): Utóhatás-kísérletek gabonafélékkel különböző triazinokkal kezelt kukorica után (After-effect expreiments with cereals after maize treated with various triazines). — Kukoricaterm. Kísérl. 1961—1964, 348—354.

UBRIZSY G. (1958a): Cönológiai kutatások agrárterületek gyomtársulásain, különös tekintettel a vegyszeres gyomirtás flóraátalakító hatására. (Coenological investigations of the weed coenoses of agricultural areas with particular regard to the floratransformative effects of chemical weed — killers). — MTA Biol. Csop. Közl. *2*, 65—78.

UBRIZSY G. (1958b): Vegyszeres gyomirtás gabonavetésekben (Chemical weed-killing in corn crops). — MTA Agrártud. Oszt. Közl. *14*, 339—411.

ÚJVÁROSI M. (1950): Hol milyn gyomok ellen védekezzünk? (Wich weeds to protect against where?). — Debreceni Mezőgazd. Kis. Int. Évk. *1*, 27—105.

ÚJVÁROSI M. (1961): A búzavetések gyomnövényzete. Búzaterm. kísérl. 1952—1956 (Weeds in wheat crops. Experiments in wheat-growing, 1952—1956). — Budapest.

ÚJVÁROSI M. (1973): Gyomnövények, Gyomirtás I—II. (Weeds and their elimination I—II). — Budapest.

Address of the author:
Dr. RÓZSA FEKETE
Department of Botany, A. J. University,
6701 Szeged, P. O. Box 428. Hungary

Acta Biologica Szeged. 27 (1—4), pp. 89—103 (1981)

SCANNING ELECTRON-MICROSCOPIC INVESTIGATIONS ON THE SPOROMORPHS OF THE UPPER PANNONIAN IN HUNGARY

M. KEDVES

Department of Botany, Attila József University, Szeged
(Received February 9, 1979)

Abstract

We have carried out scanning electron-microscopic investigations on the sporomorphs of the brown coal layers of the Upper Pannonian in Túrkeve, Emőd, Szerep. Our results are the following:

(1) A sure demonstration of the *Cathaya* genus.

(2) *Psophosphaera pseudotsugoides* is heterogeneous on the basis of the submicroscopic surface ornamentations.

(3) The proper botanical affinity of the pollen grains of *Inaperturopollenites* hiatus is not decided finally on the basis of the scanning electron-microscopic investigations, either.

(4) A more exact knowledge of the germinal area in *Arecipites vancampoae* and *Monogemmites pseudosetarius*.

(5) At the fossil forms of Amentiflorae the occurrence of ridges, as well as the number of coni per square micron are characters of taxonomical value.

Introduction

The marshy-belted vegetation of the coal layers of Túrkeve, Emőd and Szerep from the Upper Pannonian, which can be reconstructed on the basis of sporomorphs, was described by the author (1962). Later some new taxa were described as well (KEDVES and RÁKOSY, 1964; KEDVES and BOHONY, 1966). The spore-pollen assemblage is in a very good state of preservation and, therefore, it is a suitable for electron-microscopic investigations. The scanning electron-microscopic investigations have so far mainly been confined to the sporomorphs of older ages. From the younger Tertiary we have but very few literary data of this character. The scanning electron-microscopic investigation into the sporomorphs, and mainly into the pollen grains from the younger Tertiary, is justified by that this gives a comparative basis for the developmental evaluation of the submicroscopic formations of the Upper Cretaceous and Lower Tertiary. In addition to this, the knowledge of the sporomorphs of the subtropical vegetation of the Upper Tertiary is made more perfect by the scanning electron-microscopic data, being in this way comparable with the recent taxa as well.

Materials and Methods

From among the three localityes the preparations made of the coaly layers of Túrkeve and Emőd are particularly suitable for scanning electron-microscopic investigations. For making the preparations, we took the work of LEFFINGWELL and HODGKIN (1971) for our basis. Dry sporo-

morphs were carried with a glass needle on a cover plate covered with a polyvinylchloride adhesive and coated with gold. The investigations took place in the electron-microscopic laboratory in the Department of Zoology of ELTE (Loránd Eötvös University in Budapest). For the kind help, I wish to express my thanks, in this way, too, to Dr. J. KOVÁCS, lecturer at and head of the Department.

Results

1. *Laevigatosporites haardti* (R. POT. et VEN. 1934) TH. et PF. 1953 subfsp. *haardti* (Plate I, 1)

The surface magnified mildly, corresponds to the light-microscopic results: it is smooth. Magnified strongly, it is covered with small granules, taking place densely, their size being 0.15—0.2 μ.

2. *Pityosporites pristinipollinius* (TRAV. 1955) W. KR. 1971 (Plate I, 2—5)

On photomicrographs of great magnification the surface ornamentations of some parts of the pollen are different. The surfaces of the pecten and bledder are by and large identical, finely corrugated. On the other hand, the pollen body is verrucate, here and there granulated, the size of ornamental elements is 0.3—0.5 μ.

On the basis of UENO's (1974) scanning electron-microscopic data the pollen body of the recent *Pinus thunbergii* PARL. is verrucate-undulated. Thus, the connection of the fossil form with the *Pinus* genus is supported by the submicroscopic surface as well.

3. *Pityosporites alatus* (R. POT. 1931b) TH. et PF. 1953 (Plate I, 6)

The pollen body is generally ornamented with granules of 0.2 μ diameter, placed in a distance of 0.7—0.9 μ from one another. The surface of the bladder is similar, too, but the ornamentation elements take place densely.

SIVAK (1975) described the diagnostic features of the pollen grains with bladders with light- and scanning electron-microscopic methods. By reason of his scanning data, this form-species is identical with the *Cathaya* type. From the French Tertiary sediments, *Cathaya* pollen was first demonstrated by Caratini, M. VAN CAMPO and SIVAK (1972). Then SIVAK (1976) descried several new species in this genus, on the basis of pollen grains from Oligo-Miocene sediments. The genus occurred in the Far East at present, was described by CHUN and KUANG (1958) after the concise work of FERGUSON (1967) who classified here the cone *Keteleeria loehri* ENGELHARDT and KINKELIN 1911, as well, from the Pliocene (CF. FLORIN, 1963). A further Pliocene macrofossil is known from SVECHNIKOVA (1964) from the environs of the Black Sea.

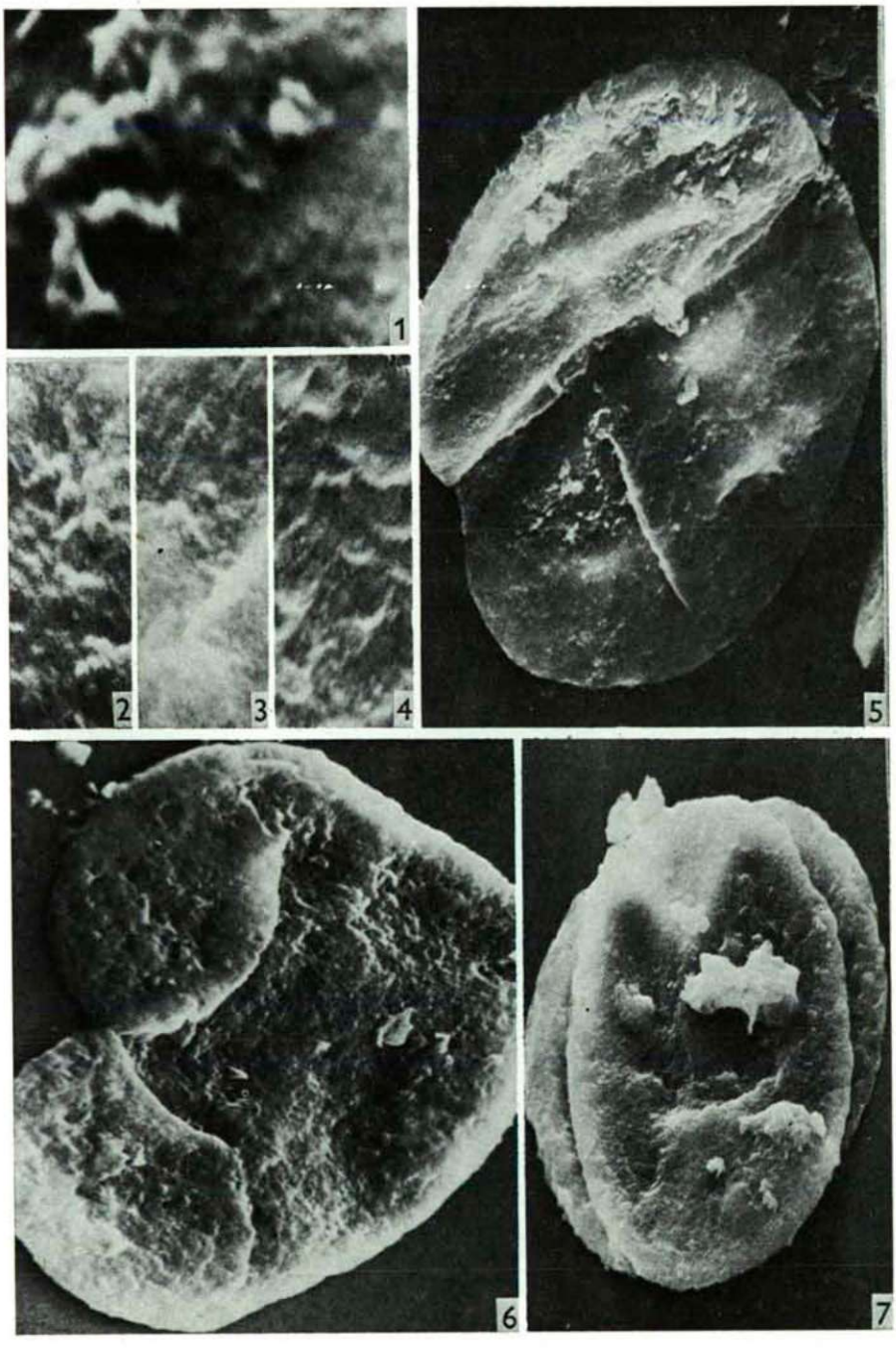
4. *Pityosporites pacltovae* W. KR. 1971 (Plate I, 7)

The baldder and the surface of the pollen body are equally corrugated, the width of elements is only different. The sculpture elements are 0.2—0.3 μ wide on the pollen body, 0.4—0.5 μ wide on the bladders

Plate I

1. *Laevigatosporites haardti* (R. POT. et VEN. 1934) TH. et PF. 1953 subfsp. *haardti*, Emőd, x10000.
2. *Pityosporites pristinipollinius* (TRAV. 1955) W. KR. 1971, pecten, Túrkeve, x10000.
3. *Pityosporites pristinipollinius* (TRAV. 1955) W. KR. 1971, pollen body, Túrkeve, x10000.
4. *Pityosporites pristinipollinius* (TRAV. 1955) W. KR. 1971, bladder, Túrkeve, x10000.
5. *Pityosporites pristinipollinius* (TRAV. 1955) W. KR. 1971, Túrkeve, x1000.
6. *Pityosporites alatus* (R. POT. 1931b) TH. et PF. 1953, Emőd, x1000.
7. *Pityosporites pacltovae* W. KR. 1971, Túrkeve, x1000.

Plate I



By reason of SIVAK's data (1975), this pollen type cannot be brought into connection, on the basis of its submicroscopic sculpture, with any recent genus.

5. *Pityosporites scopulipites* (WDH. 1933) W. KR. 1971 (Plate II, 1—3).

On the pollen body and the bladder there are equally granules of 0.15—0.2 diameter. These are placed rather densely. The ornamentation is denser on the surface of the bladders than on the pollen body.

From among the recent taxa — after HO and SZIKLAI (1972), NILSSON, S., PRAGLOWSKI and NILSSON, L. (1977) — the surface of the *Picea* genus is finely granular. According to UENO (1974), the texture of the *Pinus* and *Picea* genera is very fine. On the basis of SIVAK's (1975) work, the surface of the pollen grain of *Microcachrys tetragona* HOOK is similar.

6. *Abiespollenites absolutus* THG. 1937 (Plate II, 4)

The pollen body is ornamente with anastomosing granules giving a rugulate surface. The granules are sporadically in a heap. The surface of the pollen body is rugulate, the width of the sculpture elements is generally 0.3 μ.

The submicroscopic surface of this pollen grain resembles the type of SIVAK's (1975) *Abies* nebrodensis Mattel. It is worth mentioning that the scanning electron-microscopic picture of *Abies nordmanniana* (STEV.) SPACH. differs from the above mentioned ones very much.

7. *Piceapollenites planoides* W. KR. 1971 (Plate II, 5, 6).

A strongly magnified picture could only be made of the bladder. The surface of this is finely corrugated.

This submicroscopic surface essentially agress with SIVAK's (1975) *Picea excelsa* LINK type.

At the pollen grains with bladders, it can be established that the fine surface formations are suitable for ascertaining the botanical connections. In our material, this is particularly important in case of the *Cathaya* genus. The SEM onramentation of TAYLOR and MILLAY's (1969) *Pityosporites* fgen. from the Pennsylvanian fundamentally differs from that of the species from the Tertiary. The light-microscopic characteristics, the alveolar structure (VAN CAMPO and SIVAK 1972), together with the submicroscopic surface characteristics may have a phylogenetical significance. In this relation many more Mesozoic pollens are to be investigated.

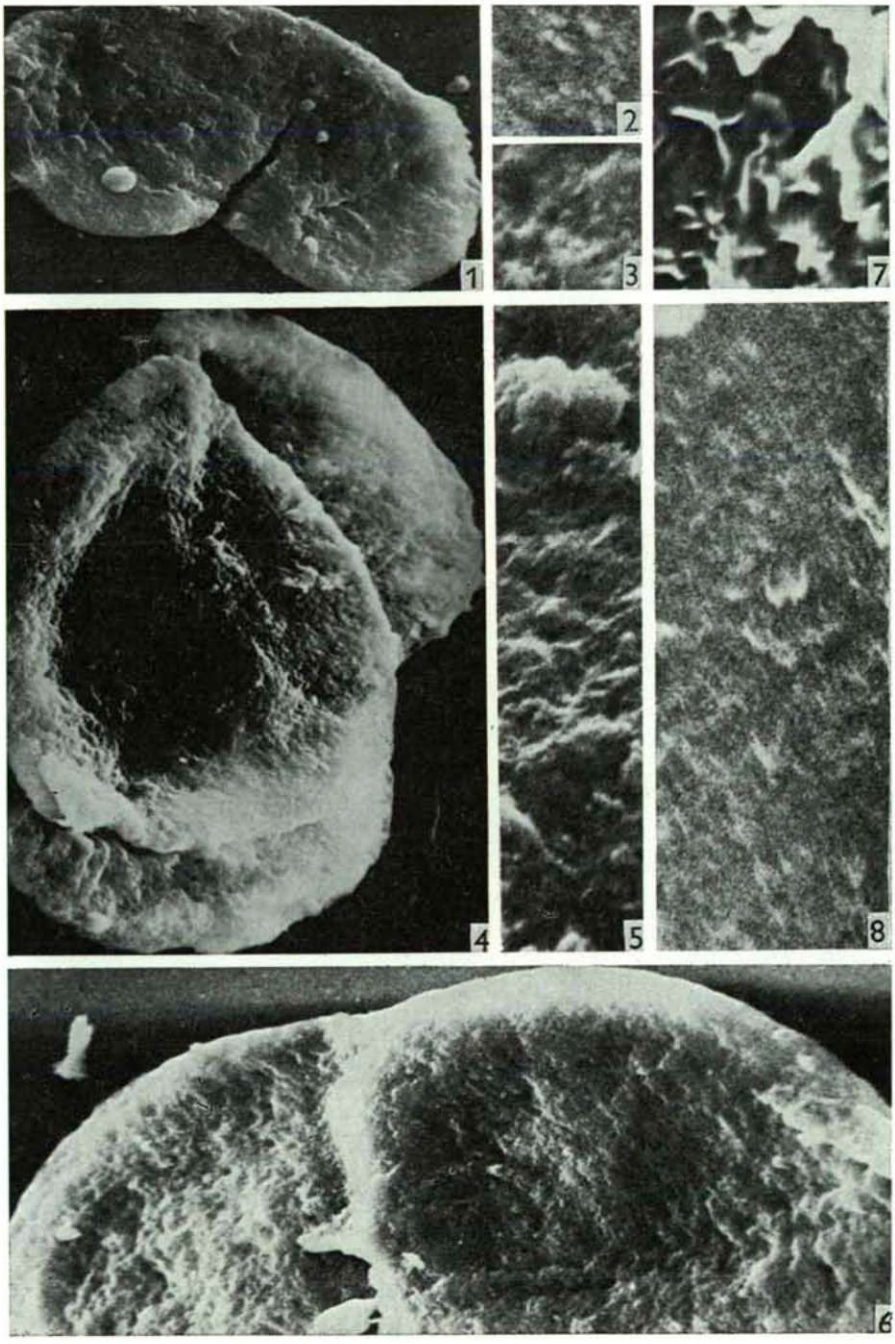
8. *Psophosphaera pseudotsugoides* W. KR. 1971 (Plate II, 7, 8)

Several specimens of this were investigated. We could separate among the light-microscopically identical forms two types by scanning electron-microscopic method. One of these was expressedly rugulate-corrugate with 0.3—0.5 μ wide elements (Plate II, 7), the other type is nearly smooth, ornamented with small, 0.15—0.2 μ wide granules, resp. with narrow verrucate elements, the width of which was below 0.2 μ.

Plate II

1. *Pityosporites scopulipites* (WDH. 1933) W. KR. 1971, Túrkeve, x1000.
2. *Pityosporites scopulipites* (WDH. 1933) W. KR. 1971, pollen body, Túrkeve, x10000.
3. *Pityosporites scopulipites* (WDH. 1933) W. KR. 1971, bladder, Túrkeve, x10000.
4. *Abiespollenites absolutus* THG. 1937, Túrkeve, x1000.
5. *Piceapollenites planoides* W. KR. 1971, bladder, Túrkeve, x10000.
6. *Piceapollenites planoides* W. KR. 1971, Túrkeve, x1000.
7. *Psophosphaera pseudotsugoides* W. KR. 1971, Emőd, x10000.
8. *Psophosphaera pseudotsugoides* W. KR. 1971, Emőd, x10000.

Plate II



On the basis of the ultrasculpture data, obtained with a carbon replica method by YAMAZAKI and TAKEOKA (1962), the first type (Plate II, 7) resembles the *Pseudotsuga* genus, while the second (Plate II, 8) the *Larix* genus. These are fossil forms and thus, at any rate, heterogeneous, but their separation is only possible by studying the submicroscopic surface.

In connection with the fossil *Tsuga* pollen grains, to be discussed below, it is to be mentioned that, unfortunately, we could only examine one of the sides of the fossil forms by scanning electron-microscopic method.

There were carried out SEM investigations by SIVAK (1973) on the recent and fossil pollen grains of this genus. The method is of differentiating value.

9. *Zonalapollenites rueterbergensis* W. KR. 1971 (Plate III, 1,2)

Concerning the taxonomy the form-genus, we are following POCOCK's work (1968).

The ornamentation of the pollen body is double on the basis of scanning data; verrucate and rugulate. Sculpture is expressed, consisting of elements of 0.4—0.6 μ size. The surface of the zone is differently corrugated, ornamented with granules.

In respect of the SEM surface, *Tsuga van campoae* SIVAK 1973 is similar to the investigated species.

10. *Zonalapollenites verruspinus* W. KR. 1971 (Plate III, 3)

It has an expressedly verrucate ornamentation with small spinae. The zone is extremely narrow, its ornamentation does not differ from that of the pollen body.

On the basis of SEM data, it is similar to *Tsuga gaussenii* SIVAK 1973.

11. *Zonalapollenites pliocaenicus* W. KR. 1971 (Plate III, 4)

The surface of the pollen body is granular. According to KRUTZSCH (1971), this is the proximal surface. The ornamental elements sporadically anastomose. The ornamentation of the narrow zone is different, it is here and there verrucae.

Of the recent species, the SEM surface of *Tsuga brunoniana* is the most similar to the fossil form (SIVAK 1973). The submicroscopic ornamentation of the *Zonalapollenites* specimens, investigated by REYRE (1973) from the Mesozoic sediments in the Sahara, does not differ essentially from the forms from the Upper Pannonian which are in an unquestionable connection with the *Tsuga* genus. This does not refer unconditionally to an identical origin; the possibility of convergence is, namely, not excluded either.

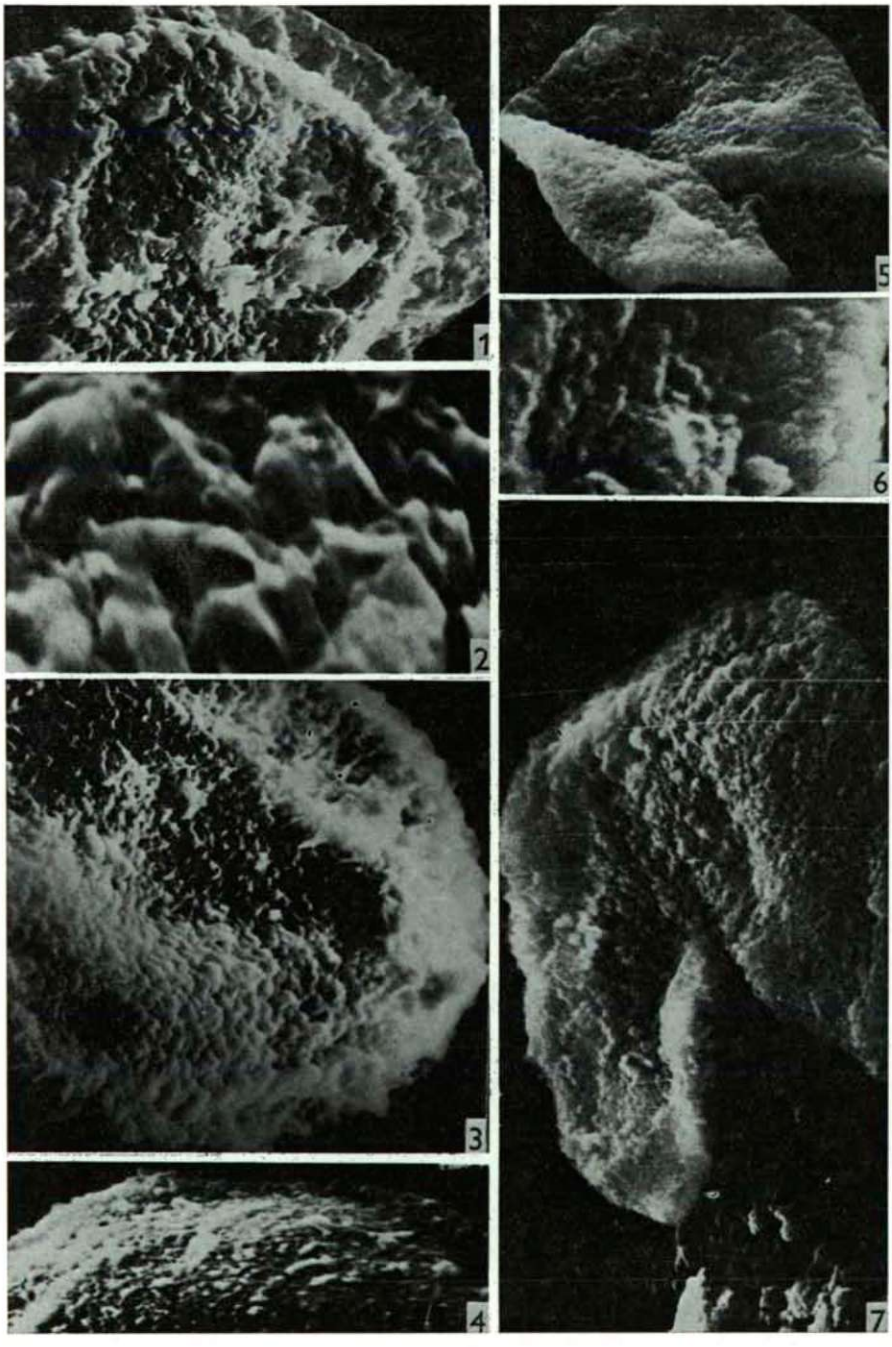
12. *Inaperturopollenites hiatus* (R. POT. 1931b) TH. et PF. 1953 (Plate III, 5—7)

Several specimens were examined and this led to the same results. We could not observe any orbicules, characteristic of recent Taxodiaceae; these probably perished as a result of fossilization. The ornamentation of the surface is granulate, verrucate, sporadically rugulate. The size of the sculptural elements is also varied, their size is 0.2—0.4 μ.

Plate III

1. *Zonalapollenites rueterbergensis* W. KR. 1971, Szerep, x1000.
2. *Zonalapollenites rueterbergensis* W. KR. 1971, central body, Szerep, x5000.
3. *Zonalapollenites verruspinus* W. KR. 1971, Túrkeve, x1000.
4. *Zonalapollenites pliocaenicus* W. KR. 1971, Emőd, x2000.
5. *Inaperturopollenites hiatus* (R. POT. 1931b) TH. et PF. 1953, Emőd, x2000.
6. *Inaperturopollenites hiatus* (R. POT. 1931b) TH. et PF. 1953, Emőd, x10000.
7. *Inaperturopollenites hiatus* (R. POT. 1931b) TH. et PF. 1953, Emőd, x2000.

Plate III



ERDTMAN (1965) investigated into several Gymnospermatophyte pollens with carbon replica method. On the basis of his data, in fossil forms, the *Cryptomeria* genus can also be taken into consideration. The first SEM data on inaperturate Gymnospermatophyte pollen grains are known by REYRE (1968). By reason of his work, the heteromorphous ornamentation occurs in the *Sequoiadendron, Cryptomeria* and *Taxodium* genera within the Taxodiaceae family. The *Taxodium* genus is the most probable. On the other hand, it is to be mentioned, as well, that a similar surface occurs in Cupressaceae, too. According to UENO (1973), the connection with *Cunninghamia lanceolata* HOOK cannot be regarded as excluded, either. According to HO and SZIKLAI (1973), the submicroscopic surface of the Taxodiaceae and Cupressaceae pollen grains investigated by them is similar — with the exception of *Sciadopitys verticillata*. According to DUHOUX (1975), the SEM surface of the Cupressaceae pollen is granular with orbicules. From among fossil forms, *Taxacites sahariensis* REYRE 1973, from Neocomian sediments, has a smooth surface or it is a little uneven, with orbicules. The surface of *Cupressacites oxycedroides* REYRE 1973 (Liassic-Neocomian) is granular, with orbicules. It is interesting that *Inaperturopollenites* sp.$_2$, from the Trias-Dogger sediments of the Sahara, has a similar surface to that of our form. The SEM surface of *Taxodiaceaepollenites distichiforme* (SIMPSON) SRIVASTAVA 1975 is, according to SRIVASTAVA (1975) granulate, sporadically with orbicules. In connection with the phylogeny of orbicules, TAYLOR's paper (1976) is important. This demonstrated orbicules and tapetal membrane on the Pennsylvanian in situ *Schopfipollenites*.

13. *Arecipites vancampoae* (KDS. et BOH. 1966) W. KR. 1970 (Plate IV, 1—3)

The perforated tectum, which forms a reticulum, is perfectly proved by the scanning method. In the neighbourhood of the colpus perforations are rare, their diameter is 0.2—0.3 μ. Here there is no reticulate structure, the diameter is extragerminally 0.8—1 μ, there is a typically net-like surface.

14. *Monogemmites pseudosetarius* (WEYL. et PF. 1957) W. KR. 1970 (Plate IV, 4, 7)

Several specimens were investigated. It is unequivocally proved by these, that in case of this species the slit of germ is a peculiar, curved colpus. The surface is not smooth. It is covered with granules of varied size, with a 0.05—0.1 μ diameter. The surface of sculptural elements is not entirely smooth, either. It is covered with tiny granules.

15. *Trivestibulopollenites betuloides* PF. 1953a (Plate IV, 5)

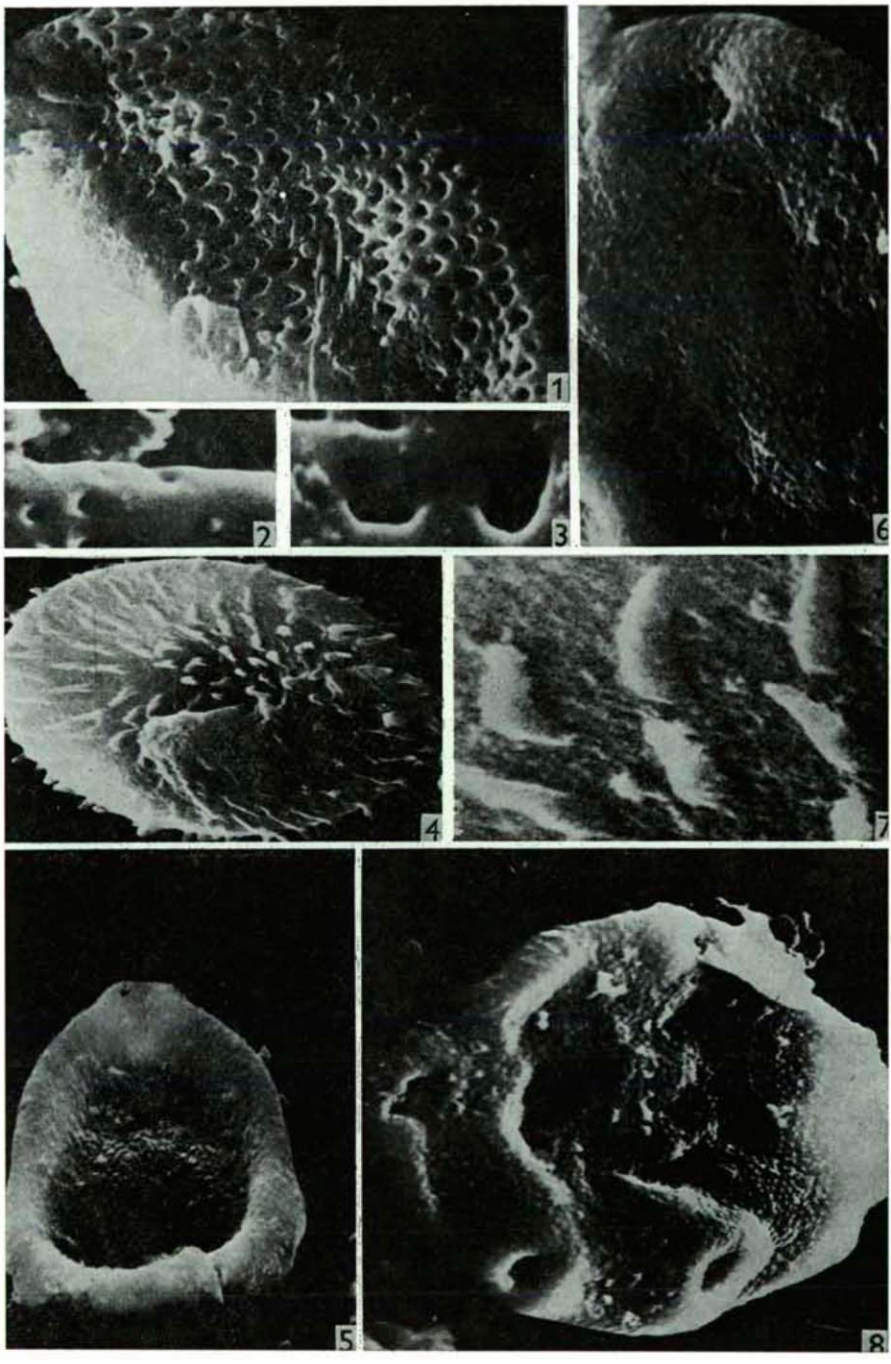
It is visible in the weakly magnified picture, too, that the surface ornamentation consists of short ridges, on which there are small coni. The width of ridges is 0.1—0.2μ.

ERDTMAN, PRAGLOWSKI and NILSSON (1963) demonstrated ridges and spinae with the carbon replica method. UENO (1975) emphasized spinae in this genus; cf.

Plate IV

1. *Arecipites vancampoae* (KDS. et BOH. 1966) W. KR. 1970, Emőd, x2000.
2. *Arecipites vancampoae* (KDS. et BOH. 1966) W. KR. 1970, Emőd, colpus, x10000.
3. *Arecipites vancampoae* (KDS. et BOH. 1966) W. KR. 1970, extragerminal exine, Emőd, x10000.
4. *Monogemmites pseudosetarius* (WEYL. et PF. 1957) W. KR. 1970, Túrkeve, x1000.
5. *Trivestibulopollenites betuloides* PF. 1953a, Emőd, x2000.
6. *Caryapollenites simplex* (R. POT. 1931) RAATZ 1937, Emőd, x2000.
7. *Monogemmites pseudosetarius* (WEYL. et PF. 1957) W. KR. 1970, Túrkeve, x10000.
8. *Pterocaryapollenites stellatus* (R. POT. 1931) RAATZ 1937, Emőd, x2000.

Plate IV



SUROVA (1975). In the *B. papyrifera* SEM picture of KOZAR and AARON (1976) ridges can hardly be recognized. On the basis of the work of NILSSON, S., PRAGLOWSKI and NILSSON, L. (1977), ridges are not expressed in every species investigated. VISSET (1972) identified his fossil forms with recent species. According to DAMBLON's SEM data (1975), the coni of *Betula pubescens* are on ridges. The fossil *Betula* pollen, examined by us, corresponds to the SEM results published by SUROVA (1975), particularly to those found in the specimens in Plate 51, figs. 1, 2.

For a summary it is to be mentioned that this problem may be cleared up in detail by the SEM investigation into the recent *Betula* species.

16. *Caryapollenites simplex* (R. POT. 1931) RAATZ 1937 subfsp. *simplex* (Plate IV, 6).

The surface is covered with coni characteristic of Juglandaceae. The diameter of the basis of coni is 0.2—0.3 μ. Coni density 3—4 per square micron.

KEDVES and STANLEY (1975) demonstrated, on recent pollen grains, the taxonomical importance of the number of coni per square micron, in this genus. The number of coni per square micron is higher (4—5) on the surface of *Caryapollenites triangulus* (PF. 1953a) W. KR. 1961 at the Mississippi, from the Lower Eocene, investigated by the scanning electron-microscopic method. In the diameter of the coni basis there is no difference between the fossil *Carya* pollen grains from the Lower Eocene and Upper Pannonian.

17. *Pterocaryapollenites stellatus* (R. POT. 1931) RAATZ 1937 (Plate IV, 8)

The diameter of coni covering the surface is generally 0.2 μ. The number of coni per square micron is 4—6. Thus, the diameter of the basis of coni, as well as the number per square micron are considerably different in the same period in case of the two Juglandaceae genera.

The comparative SEM data see in the work of STONE and BROOME (1975).

18. *Alnipollenites verus* R. POT. 1934 (Plate V, 1,5)

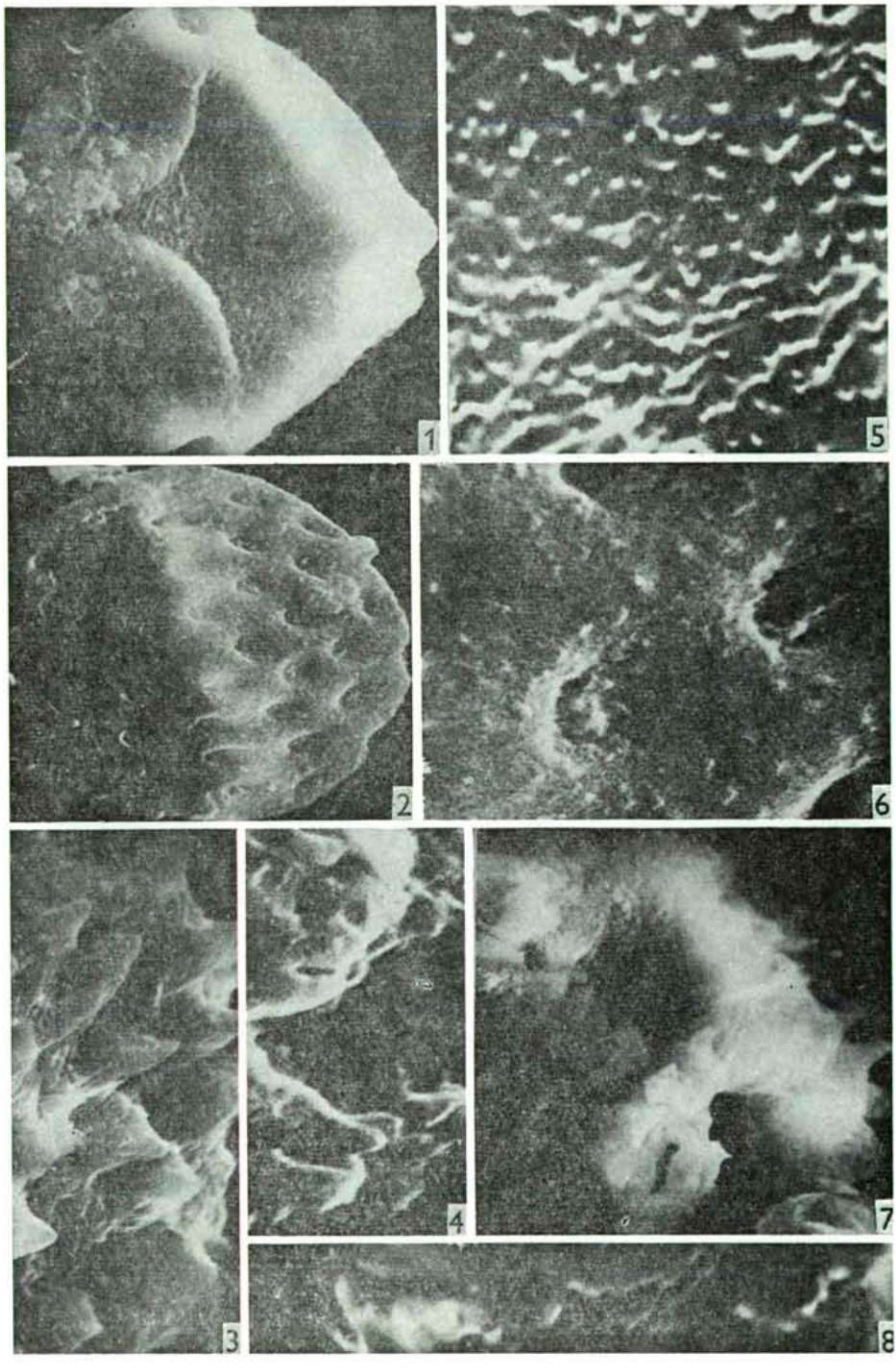
The investigated sediments are rich in fossil Alnus pollen grains and several speciments have got under scanning electron-microscopic investigation. Among these, there were pollens of three, four and five germinalia. The most frequent were those of four germinalia. These are, therefore, published. Between the number of pores on the surface sculpture no connection could be established. The surface is covered with coni, the diameter of the basis of which is 0.2—0.3 μ, and 5—6 per square micron. Coni take very often place on ridges.

Recent data are: MARTIN (1969), UENO (1975), NILSSON, S., PRAGLOWSKI and NILSSON, L. (1977). By KEMPF (1973), TEM and SEM data were published of fossil *Alnus* pollen grains from the Miocene *(A. metaplasmus)*. In SRIVASTAVA's (1975) SEM picture of the Maastrichtian *Polyvestibulopollenites verus* (R. POTONIÉ) THOM-

Plate V

1. *Alnipollenites verus* R. POT. 1934, Emőd, x2000.
2. *Chenopodiipollenites multiplex* (WEYL. et PF. 1957) W. KR. 1966, Túrkeve, x2000.
3. *Tubulifloridites grandis* E. NAGY 1969, Emőd, x2000.
4. *Tubulifloridites grandis* E. NAGY 1969, Emőd, x10000.
5. *Alnipollenites verus* R. POT. 1934, Emőd, x10000.
6. *Chenopodiipollenites multiplex* (WEYL. et PF. 1957) W. KR. 1966, Túrkeve x10000.
7. *Cichoreacidites* fsp. cf. *spinosus* SAH 1967, Emőd, x2000.
8. *Cichoreacidites* fsp. cf. *spinosus* SAH 1967, Emőd, x10000.

Plate V



SON et PFLUG 1953 no ridges can be recognized. The qualitative characters established by us can also be observed on SUROVA's (1975) fossil *Alnus* pollen grains (Pl. 50, 1,2).

19. *Chenopodiipollenites multiplex* (WEYL. et PF. 1957) W. KR. 1966 (Plate V, 2,6)

The surface is covered with coni, the diameter of which is 0.2 μ. The density of coni per square micron is generally three. The surface of the operculum covering the pore is granular.

From the point of view of the botanical connection between the periporate pollen grains, it was an advancement when TSUKADA (1967) separated the Chenopodiaceae and Amaranthaceae pollen grains from each other with carbon replica method. On the other hand, RIOLLET and BONNEFILLE (1976) demonstrated convergence between Amaranthaceae, Chenopodiaceae, and Caryophyllaceae with scanning electron-microscopic method. There is some similarity between the *Celosia* and *Digera* genera and their fossil forms, the tectum of these is, however, perforated. Cf. with the SEM data of the *Celosia* pollen at ZANDONELLA and LECOQ (1972). Our species investigated, after SKVARLA and NOWICKE (1976), resembles *Beta trigyna*. From among NOWICKE's (1975) SEM data, the type *Amaranthus spinosus* may also come into consideration. The work of KOZAR and AARON (1976) raises the possibility of further connections.

MARTIN's (1969) pollen from the Pleistocene is similar to our fossil form. A further fossil datum is known from SUROVA (1975). The SEM picture of *Chenopodiipollis microporatus* (NAKOMAN) LIU 1978 is published by SUNG TZE CHEN and TSAO LIU (1978). The tectum of this is densely perforated. Thus the surface is essentially reticulate. It differs in this from the species investigated by us.

20. *Tubulifloridites grandis* E. NAGY (1969 Plate V, 3,4)

At the basis of the large sculpture elements and at the surface, the tectum is perforated what can generally not be demonstrated by light-microscopic method. The diameter of perforations is between 0.3 and 0.4 μ.

21. *Cichoreacidites* fsp. cf. *spinosus* SAH 1967 (Plate V, 7,8)

The taxonomy of the fenestrate Compositae pollen grains is not elaborated as yet. *Fenestrites spinosus* was invalidly described by VAN der HAMMEN (1956) and later validated by GERMERAAD, HOPPING and MULLER (1968), after separating the lectogenotype. On the other hand, Sah described the *Cichoreacidites* genus in 1967, using for the name of species similarly the name "spinosus". The validity of this latter genus is unquestionable. It is, however, necessary to describe the differentiating features of the pollen group exactly and elaborate this taxonomically in the last resort, so much the more because this is one of the developed angiospermous pollen types and is very considerable stratigraphically, as well, because it only occurred in the Upper Tertiary, in the Pannonian, within this first of all in the Upper Pannonian.

The arrangement of lacunae and characteristic spinae is well demonstrated by the scanning electron-microscopic data. The perforations of the tectum, which give a reticulate character to the interlacunar exine and to the basis of the large spinae, can only be demonstrated by this method. The diameter of perforations is 0.2—0.3 μ.

Discussion

As sporomorphs of heterogeneous character have got under scanning electron-microscopic investigation, the character of results and thus the value of SEM data are changing. At any rate, compared with the light-microscopic results, the scanning method has demonstrated qualitatively new characters in these cases as well. The sur-

face qualified as smooth with light-microscopic method, is sculptured *Laevigatosporites haardti haardti* with scanning method. Summarizing our experiences achieved so far, at miospores we can come to the conclusion that in the case of the surfaces strongly sculptured even light-microscopically, in most cases no further submicroscopic characters can be demonstrated by the scanning method either, opposite to the forms qualified for scabrate. It is not excluded that after the development of the scanning method, the results achieved so far must be put in a new light. The question of botanical connections in case of the pine pollen grains with bladders has considerably been promoted by SEM data. The *Pinus, Picea, Abies* genera were partly supported, the *Cathaya* genus was first demonstrated from the Carpathian basin with scanning method. Further on, the *Microcachrys* genus can also be supposed on the basis of the submicroscopic surface of the pollen grain.

Psophosphaera pseudotsugoides is heterogeneous by reason of SEM data; one part of it can be connected with the *Pseudotsuga,* the other part with the *Larix* genus. The fossil *Tsuga* pollen grains can be brought into connection with SIVAK's data (1973). The fossil Taxodiaceae-Cupressaceae *(Inaperturopollenites hiatus)* pollen grains demand further scanning electron-microscopic investigations, as well.

The surface morphology of *Arecipites vancampoae* and *Monogemmites pseudosetarius* was essentially improved by SEM data.

Within Amentiflorae, in case of the *Betula* genus the number of ridges, in case of *Carya* and *Pterocarya* the number of coni per square micron are particularly interesting taxonomical data. The SEM knowledge of the periporate pollen grains demands several investigations, as well, similarly also that of Compositae.

References

CARATINI, C., VAN CAMPO, M. ET SIVAK, J. (1972): Pollen de *Cathaya* (Abietaceae) au Tertiaire en France. — Pollen et Spores *14*, 169—172.

DAMBLON, F. (1975): Sputtering, a New Method for Coating Pollen Grains in Scanning Electron Microscopy. — Grana *15*, 137—144.

DUHOUX, E. (1975): L'aperture dans l'exine et dans l'intine externe du pollen de *Juniperus chinensis* L., et de *Juniperus communis* L. — Pollen et Spores *17*, 191—201.

ERDTMAN, G. (1965): Pollen and Spore Morphology (Plant Taxonomy Gymnospermae, Bryophyta (Text) (An Introduction to Palynology. III). — Almqvist-Wiksell, Stockholm.

ERDTMAN, G., PRAGLOWSKI, J. and NILSSON, S. (1963): An Introduction to a Scandinavian Pollen Flora. II. — Almqcist-Wiksell/Gebers, Uppsala.

FERGUSON, D. K. (1967): On the phytogeography of Coniferales in the European Cenozoic. — Palaeogeography, Palaeoclimatol., Palaeoecol. *3*, 73—110.

GERMERAAD, J. H., HOPPING, C. A. and MULLER, J. (1968): Palynology of Tertiary sediments from tropical areas. — Review of Palaeobotany and Palynology *6*, 189—348.

GULLVAG, B. M. (1966): The fine structure of some Gymnosperm pollen walls. — Grana Palynologica *5*, 435—575.

HO, R. H. and SZIKLAI, O. (1972): On the pollen morphology of *Picea* and *Tsuga* species. — Grana *12*, 31—40.

HO, R. H. and SZIKLAI, O. (1973): Fine structure of the pollen surface of some Taxodiaceae and Cupressaceae species. — Rev. of Palaeobotan. Palynol. *15*, 17—26.

KEDVES, M. (1962): Palynologic investigations on coals of the Upper Pannonian I. — Acta Biol. Szeged, *8*, 77—81.

KEDVES, M. et BOHONY, E. (1966): Observation sur quelques pollens de palmiers provenant des couches Tertiaires de Hongrie. — Pollen et Spores *8*, 141—147.

KEDVES, M. et RÁKOSY, I. (1964): Intrabaculisporis n. fgen. du Pannonien supérieur de Hongrie. — Pollen et Spores *6*, 593—596.

KEDVES, M. and STANLEY, E. A. (1976): Electronmicroscopical investigations of the Normapolles group and some other selected European and North American Angiosperm pollen II. — Pollen et Spores *18*, 105—127.

KEMPF, E. K. (1973): Transmission Electron Microscopy of fossil spores. — Palaeontology *16*, 787—797.

KOZAR, F. and AARON, T. H. (1976): Some electron photomicrographs of allergic pollen grains of plants of the Canadian prairies. — Pollen et Spores *18*, 217—230.

KRUTZSCH, W. (1961): Beitrag zur Sporenpaläontologie der präoberoligozänen kontinentalen und marinen Tertiärablagerungen Brandenburgs. — Berichte der Geol. Gesellschaft *4*, 290—343.

KRUTZSCH, W. (1966): Zur Kenntnis der präquartären periporaten Pollenformen. — Geologie *15*, BH 55, 16—71.

KRUTZSCH, W. (1970): Atlas der mittel—und jungtertiären dispersen Sporen — und Pollen — sowie der Mikroplanktonformen des nördlichen Mitteleuropas. Lief. VII. Monoporate, monocolpate, longicolpate, dicolpate, und ephedroide (polyplicate) Pollenformen. — VEB Gustav Fischer Verlag, Jena.

KRUTZSCH, W. (1971): Atlas der mittel- und jungtertiären dispersen Sporen- und Pollen- sowie der Mikroplanktonformen des nördlichen Mitteleuropas. Lief. VI. Coniferenpollen (Saccites und "Inaperturates"). — VEB Gustav Fischer Verlag, Jena.

LEFFINGWELL, H. A. and HODGKIN, N. (1971): Techniques for preparing fossil palynomorphs for study with the scanning and transmission electron microscopes. — Rev. Palaeobotan. Palynol. *11*, 177—199.

MARTIN, B. S. (1969): Pollen analysis and the scanning electron microscope. — Scanning Electron Microscopy/1969, 89—102.

NAGY, E. (1969): Palynological elaborations the miocene layers of the Mecsek Mountains. — Ann. Inst. — Geol. Publ. Hung. *52*, 237—649.

NILSSON, S., PRAGLOWSKI, J. and NILSSON, L. (1977): Atlas of airborne pollen grains and spores in Northern Europe. — Natur och Kultur, Stockholm.

NOWICKE, J. W. (1975): Pollen Morphology in the Order Centrospermae. — Grana *15*, 51—77.

POCOCK, S. A. (1968): *Zonalapollenites* PFLUG 1953 and related genera. — Taxon *17*, 639—641.

POTONIÉ, R. (1931): Pollenformen aus tertiären Braunkohlen. — 3 Mitt. — Jb. Preuss Geol. Landesanst. f. 1931, *52*, 1—7.

POTONIÉ, R. (1934): Zur Mikrobotanik des eozänen Humodils des Geiseltals. — Arb. aus Inst. Paläobotanik u. Petrogr. Brenngesteine *4*, 25—125.

POTONIÉ, R. —VENITZ, H. (1934): Zur Mikrobotanik des miozänen Humodils der niederrheinischen Bucht. — Arb. aus Inst. Paläobotanik u. Petrogr. Brenngesteine *5*, 5—53.

POTONIÉ, R. (1958): Synopsis der Gattungen der Sporae dispersae. II. Teil: Sporites (Nachträge), Saccites, Aletes, Praecolpates, Polyplicates, Monocolpates. — Beih. Geol. Jb. *31*, 1—114.

RAATZ, G. V. (1937): Mikrobotanisch — stratigraphische Untersuchungen der Braunkohle des Muskauer Bogens. — Arb. Preuss. Geol. Landesanst. N. F. *183*, 1—48.

REYRE, Y. (1968): La sculpture de l'exine des pollens des Gymnospermes et des Chlamydospermes et son utilisation dans l'identification des pollens fossiles. — Pollen et Spores *10*, 197—220.

REYRE, Y. (1973): "Palynologique du Mésozoique Saharien" Traitement des donnés par l'information et applications à la Stratigraphie et à la Sédimentologie. — Mém. du Mus. Nat. d'Hist. Nat. N. S. C., *27*, 1—284.

RIOLLET, G. et BONNEFILLE, R. (1976): Pollen des Amaranthacées du bassin du lac Rodolphe (Afrique Orientale) Détermination générique et spécifique. — Pollen et Spores *18*, 67—92.

SAH, S. C. D. (1967): Palynology of an Upper Neogene profile from Rusizi Valley (Burundi). — Mus. Royal de l'Afrique Centrale *8*, 1—173.

SIVAK, J. (1973): Observations nouvelles sur les grains de pollen de Tsuga. — Pollen et Spores *15*, 387—457.

SIVAK, J. (1975): Les caractères de diagnose des grains de pollen à ballonnets. — Pollen et Spores *17*, 349—421.

SIVAK, J. (1976): Nouvelles espèces du genre *Cathaya* d'après leurs grains de pollen dans le Tertiaire du Sud de la France. — Pollen et Spores *18*, 243—288.

SIVAK, J. et CARATINI, C. (1973) Determination de pollens de *Pinus américains* dans le Miocên inférieur des Landes (France), d'après la structure de l'ectexine de leurs balonnets. — Grana *13*, 1—17.

SKVARLA, J. J. and LARSON, D. A. (1965): An electron microscopic study of pollen morphology in the Compositae with special reference of the Ambrosiinae. — Grana Palynologica *6*, 210—269.

SKVARLA, J. J. and NOWICKE, J. W. (1976): Ultrastructure of Pollen Exine in Centrospermous Families. — Plant. Syst. Evol. *126*, 55—78.
SRIVASTAVA, S. K. (1975): Maastrichtian microspore assemblages from the interbasaltic lignites of Mull. Scotland. — Palaeontographica B, *150*, 125—156.
STONE, D. E. and BROOME, C. R. (1975): World Pollen and Spore Flora 4, Angiospermae Juglandaceae A. Rich. ex Kunth. — Almqvist et Wiksell, Stockholm.
SUNG TZE CHEN and TSAO LIU (1978): Early Tertiary spores and pollen grains from the coastal region of Bohai (Chinese, with English summary). — Nanjing Inst. of Geol. and Paleontol., Acad. Sinica.
Сурова, Т. Г. (1975): Электронно-микроскопическое исследование пыльцы и спор растений. — Акад. Наук СССР Совет Ботанических Садов Институт Географии, 1—85.
TAYLOR, TH. N. (1976): The ultrastructure of Schopfipollenites: Orbicules and tapetal membranes. — Amer. J. Bot. *63*, 857—862.
TAYLOR, TH. N. and MILLAY, M. A. (1969): Application of the scanning electron microscope in Paleobotany. — Scanning Electron Microscopy 1969.
THIERGART, F. (1937): Die Pollenanalyse der Niederlausitzer Braunkohle, besonders im Profil der Grube Marga bei Seftenberg. — Jb. Pr. Geol. Landesanst. f. 1937, *58*, 282—351.
THOMSON, P. W. und PFLUG, H. D. (1953): Pollen und Sporen des mitteleuropäischen Tertiärs. — Palaeontographica B, *94*, 1—138.
TOMB, A. S. (1975): Pollen Morphology in Tribe Lactuceae (Compositae). — Grana *15*, 79—89.
TOMB, A. S., LARSON, D. A. and SKVARLA, J. J. (1974): Pollen morphology and detailed structure of family Compositae, tribe Cichorieae. I. Subtribe Stephanomeriinae. — American J. of Bot. *61*, 486—498.
TRAVERSE, A. (1955): Pollen Analysis of the Brandon Lignite of Vermont. — Bureau of Mines Rep. Investig. *5151*, 1—107.
TSUKADA, M. (1967): Chenopod and Amaranth Pollen: Electron-Microscopic Identification. — Science *157*, 80—82.
UENO, J. (1973): The Fine Structure of Pollen Surface IV Gymnospermae (A) *(Araucaria, Cryptomeria, Cunninghamia, Ephedra, Sciadopitys* and *Tsuga)*. — Rep. of Fac. of Sci. Shizuoka Univ. *8*, 101—115.
UENO, J. (1974): The Fine Structure of Pollen Surface V. Gymnospermae (B) *(Abies, Dacrydium, Hesperopeuce, Larix, Picea, Pinus, Podocarpus, Taiwania)*. — Rep. of Fac. of Sci. Shizuoka Univ. *9*, 79—94.
UENO, J. (1975): The Fine Structure of Pollen Surface VI. Amentiferae. — Rep. of Fac. of Sci. Shizuoka Univ. *10*, 109—118.
VAN CAMPO, M. et SIVAK, J. (1972): Structure alvéolaire de l'ectexine des pollens à ballonnets des Abiétacées. — Pollen et Spores *14*, 115—141.
VAN DER HAMMEN, TH. (1956): A palynological systematic nomenclature. — Bol. Geol. (Bogota) *4*, 63—101.
VISSET, L. (1972): Application de la technique de microscopie éléctronique à balayage à la palynologie fossile: la tourbière de la "Butte des Roches" en Grande-Brière (Loire Atlantique). — C.R. Acad. Sc. Paris (sér D), 353—356.
WEYLAND, H. und PFLUG, H. D. (1953): Die Pflanzenreste der pliozänen Braunkohle von Ptolemais in Nordgriechenland I. — Palaeontographica B, *102*, 96—109.
WODEHOUSE, R. P. (1933): Tertiary Pollen II. The poil shales of the Green River Formation. — Bull. Torrey Bot. Club *60*, 479—524.
YAMAZAKI, T. and TAKEOKA, M. (1962): Electron-microscope investigations of the fine details of the pollen grain surface in Japanese Gymnosperms. — Grana Palynologica *3*, 3—12.
ZANDONELLA, P. et LECOCQ. M. (1977): Morphologie pollinique et mode de pollinisation chez les Amaranthaceae. — Pollen et Spores *19*, 119—141.

Address of the author:
Dr. M. KEDVES
Department of Botany, A. J. University,
H-6701 Szeged, P. O. Box 428. Hungary

Acta Biologica Szeged. 27 (1—4), pp. 105—115 (1981)

TRANSMISSION ELECTRON MICROSCOPIC (TEM) INVESTIGATIONS ON UPPER CRETACEOUS SPORES FROM VILA FLOR (PORTUGAL)

M. KEDVES and Á. PÁRDUTZ

Department of Botany, Attila József University, Szeged and Institute of Biophysics, Biological Center of the Hungarian Academy of Sciences, Szeged

(Received November 28, 1979)

Summary

TEM investigations were performed on spores of the Upper Cenomanian sediments of Vila Flor. It was found that 1. The wall matrix of three species of the form-genus (fgenus) *Leiotriletes* is homogeneous. In the inner part of the wall there are channells or cavities running more or less parallel with the surface. In the case of one form-species (fsp) the cavities continue in radial channels in the exospore. The diameter of the channels parallel with the surface has a taxonomical value. 2. The exospore of two species from the fgenera *Cicatricosisporites* and *Polypodiaceosporites* is completely homogeneous without channels. 3. The exospore of *Ariadnaesporites* is not completely homogeneous. Ultrastructure of the perispore and that of the acrolamellae are identical; they are composed of irregular sporopollenin particles while the ultrastructure of the elaters is homogeneous. The exospore of the fsp from the fgenus Microfoveolatosporis is homogeneous as well.

Introduction

TEM investigations were performed on spores of palaeozoic forms (PETTIT, 1966) and on spores of heterosporic plants (KEMPF, 1969a, 1969b, 1971; KEDVES 1978). There are relatively few data known about wall ultrastructure of fossile isosporic plants (KEDVES and PÁRDUTZ, 1973).

Ample palynological investigations are in progress on Upper Cretaceous sediments in Portugal. The first step of these investigations covers the angiospermous pollens e.g. DINIZ, KEDVES and SIMONCSICS (1974/1977), KEDVES and HEGEDŰS (1975), KEDVES and PITTAU (1979). After the investigation of the angiospermous pollens, the results on spores and on the pollens of Gymnospermatophyta will be presumably published in a monograph. Before this new data are necessary for the description of several new taxa. At present such data can be obtained by TEM method. Present work summarizes the introductory part of authors' investigations on the Upper Cenomanian sediments of Vila Flor.

Materials and Methods

A geological survey of the site of Vila Flor is published by DINIZ, KEDVES and SIMONCSICS (1974/1977). The methods are described by KEDVES and PÁRDUTZ (1970). This time the spores embedded in blocks were photographed again by light microscope. Only the short description of these pictures is to be published here because in a subsequent taxonomic work all the fossile spores will

be identified and published. From the main spore types of the Portuguese Upper Cretaceous the spores of fgenera *Leiotriletes*, *Cicatricosisporites*, *Ariadnaesporites* and *Microfoveolatosporis* were investigated by the TEM method.

Results

Fgenus: *Leiotriletes* (NAUMOVA 1937) R. POT, et KRP. 1954

1. *Leiotriletes* fsp XV./1 (Table I, 1,2)

Light microscopic characters: The outline is triangular with convex sides. The exospore is 2—3 μm thick. Laesurae of the square mark do not reach the equator, r=3/4—4/5; diameter 73 μm.

TEM characters: The wall is homogeneous, no layers with different electron-affinity can be distinguished, but in the inner third part cavities or channels running parallel with the surface occur. Exceptionally, these may reach the middle of the wall. Their diameter is variable: 0.17—0.5 μm; mostly about 0.3 μm.

2. *Leiotriletes* fsp XIV./1 (Table I, 3, 4)

Light microscopic characters: It is a triplanoid form. The outline is triangular with convex sides. The exospore is 2—2.5 μm thick. Laesurae of the square mark do not reach the equator, r—3/4; diameter=70 μm.

TEM characters: The wall is homogeneous permeated by two kinds of channels. In the inner third part of the wall channels running irregularly or parallel with the surface occur. One part of these channels lead into channels radially oriented and reaching the surface. The diameter of the radial channels is 0.05 μm, the irregular inner channels has a diameter of 0.04—0.14 μm, mostly about 0.07 μm.

3. *Leiotriletes* fsp XIV./3 (Table II, 1—3)

Light microscopic characters: The outline is triangular with straight on concave sides. The wall is 2—3 μm thick. The laesurae of the square mark reach the equatorial contour (or nearly so), r=4/5—5/5; the diameter is 75 μm.

TEM characters: The wall is homogeneous. In the inner part channels and cavities running parallel with the surface occur, relatively densely. They reach about the middle of the wall but they occur only in the inner third part densely. Their diameter is variable: 0.02—0.2 μm, mostly 0.5—0.7 μm.

Fgenus: *Cicatricosisporites* R. POT. et GELL. 1933

1. *Cicatricosisporites* fsp XIII./2 (Table II, 4,5, Table III, 1,2)

Light microscopic characters: It is a triplan form, the width of four striae and muri is 20 μm. The longitudinal axis is 44 μm long.

TEM characters: The exine is completely homogeneous. In some places an inner thin layer shows higher electron affinity (Table II, 4, Table III, 2); this is the artefact of the preparation. From serial cuttings it can be established that the proximal part is nearly smooth. The caniculate sculpture of the distal part is variable on the different parts of the spore; there are partly stocky and wide muri and on the other hand occur high protuberances too. These can be properly seen on all the four photos (Table II, 4, 5, Table III, 1, 2).

Fgenus *Polypodiaceoisporites* R. POT. 1956 non 1951

1. *Polypodiaceoisporites* fsp XI./2 (Table IV, 1, 2)

Light microscopic characters: The equatorial contour is triangular with slightly convex or concave sides. The cingulum is 4.5 μm wide. The laesurae of the square

Table I

1, 2 *Leiotriletes* fsp XV/1, exospore cross section, x20000
3, 4 *Leiotriletes* fsp XIV/1, exospre cross section, x20000

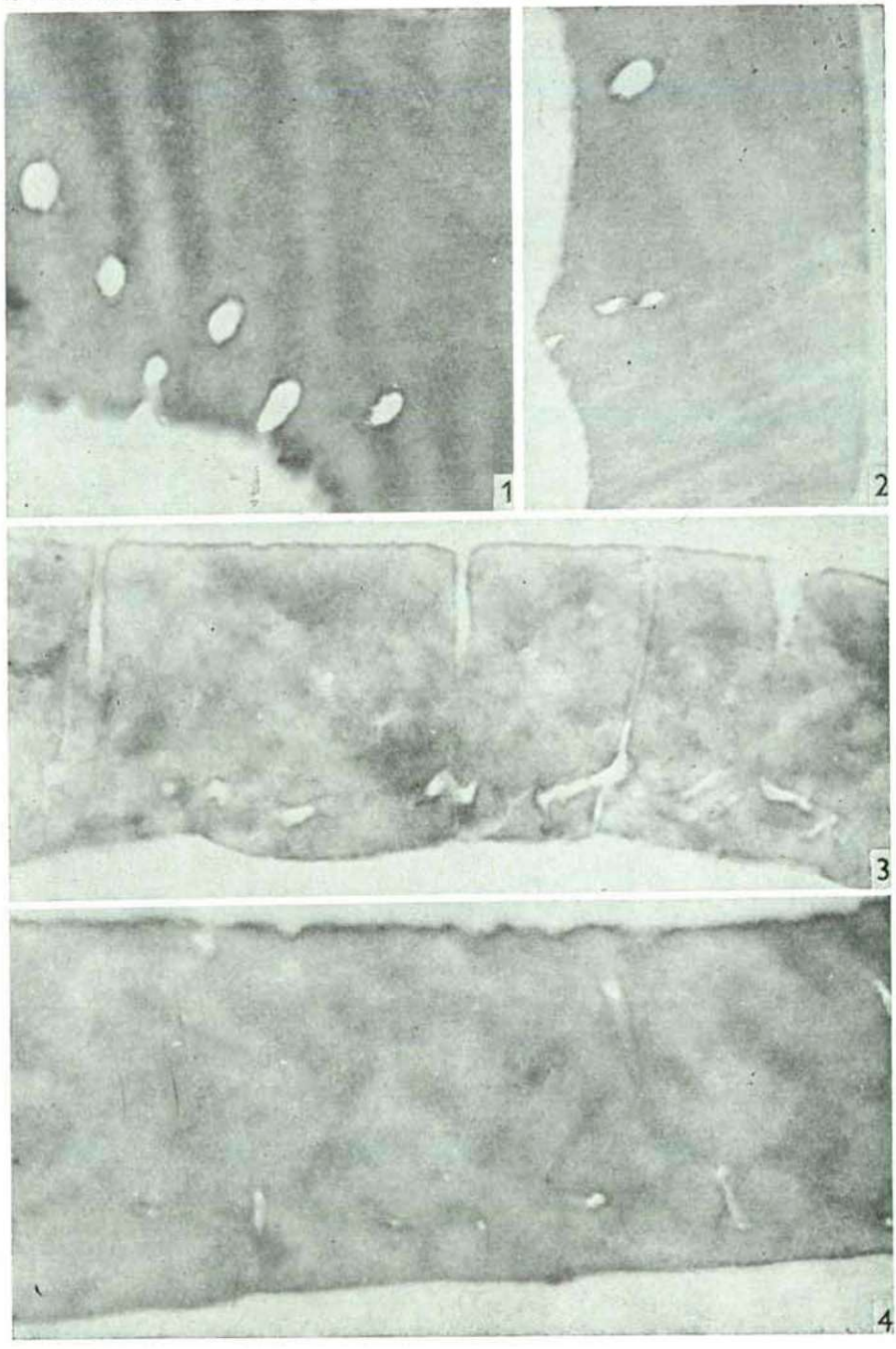


Table II

1—3, *Leiotriletes* fsp XIV/3; 1, 2 exospore cross section x20000, 3 exospore cross section x10000
4, 5, *Cicatricosisporites* fsp XIII/2 spore cross section, x5400

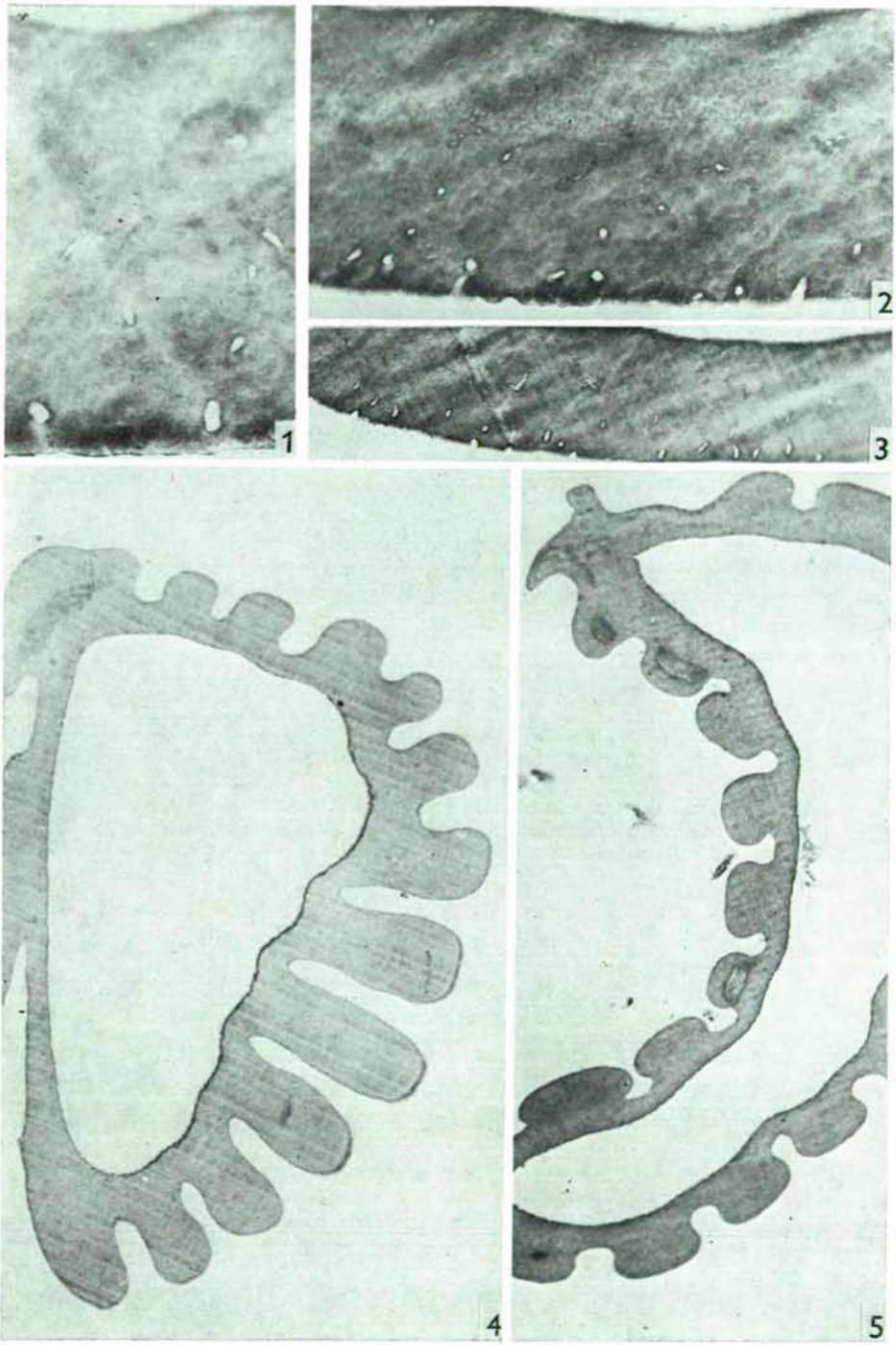
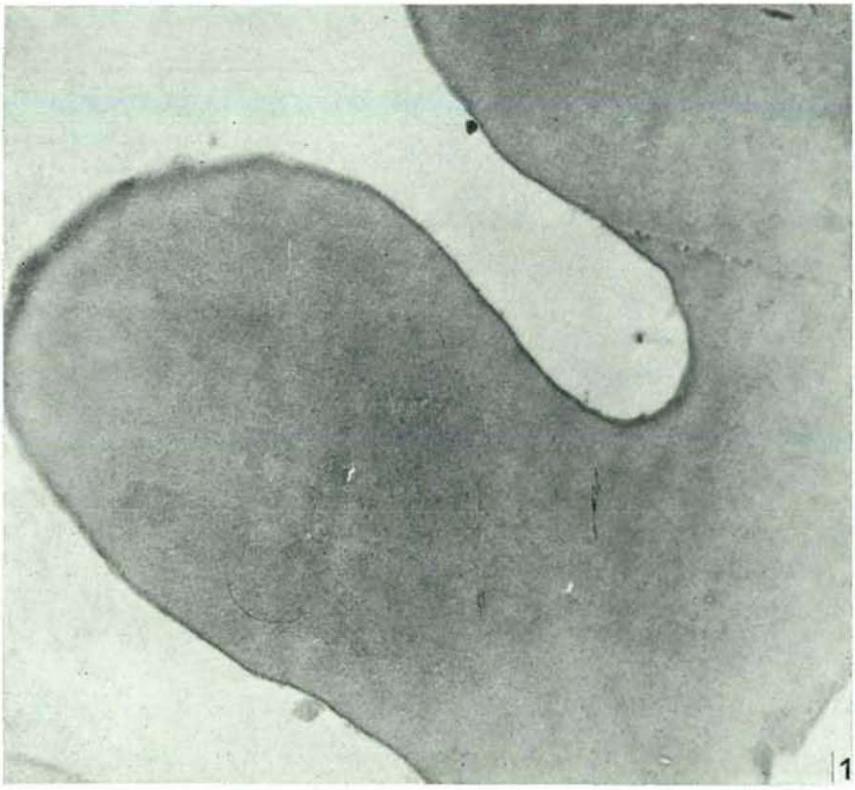


Table III

1, 2 *Cicatricosisporites* fsp XIII/2, exospore cross section, x20000



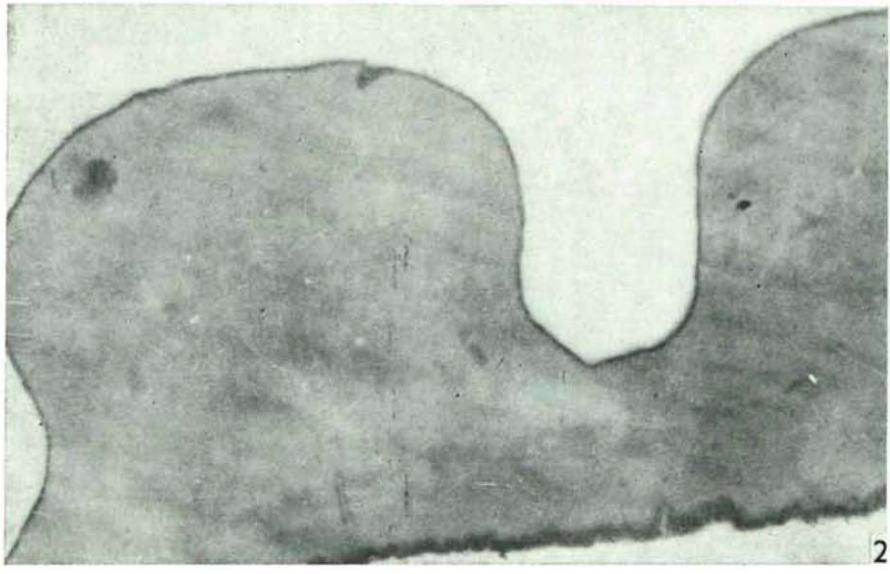


Table IV

1 *Polypodiaceoisporites* fsp XI/2, spore cross section, x5400
2 *Polypodiaceoisporites* fsp XI/2, spore cross section, x6600
3 *Ariadnaesporites* fsp XIII/3, exospore and perispore cross section, x10000
4 *Ariadnaesporites* fsp XIII/3, perispore cross section with elaters, x10000

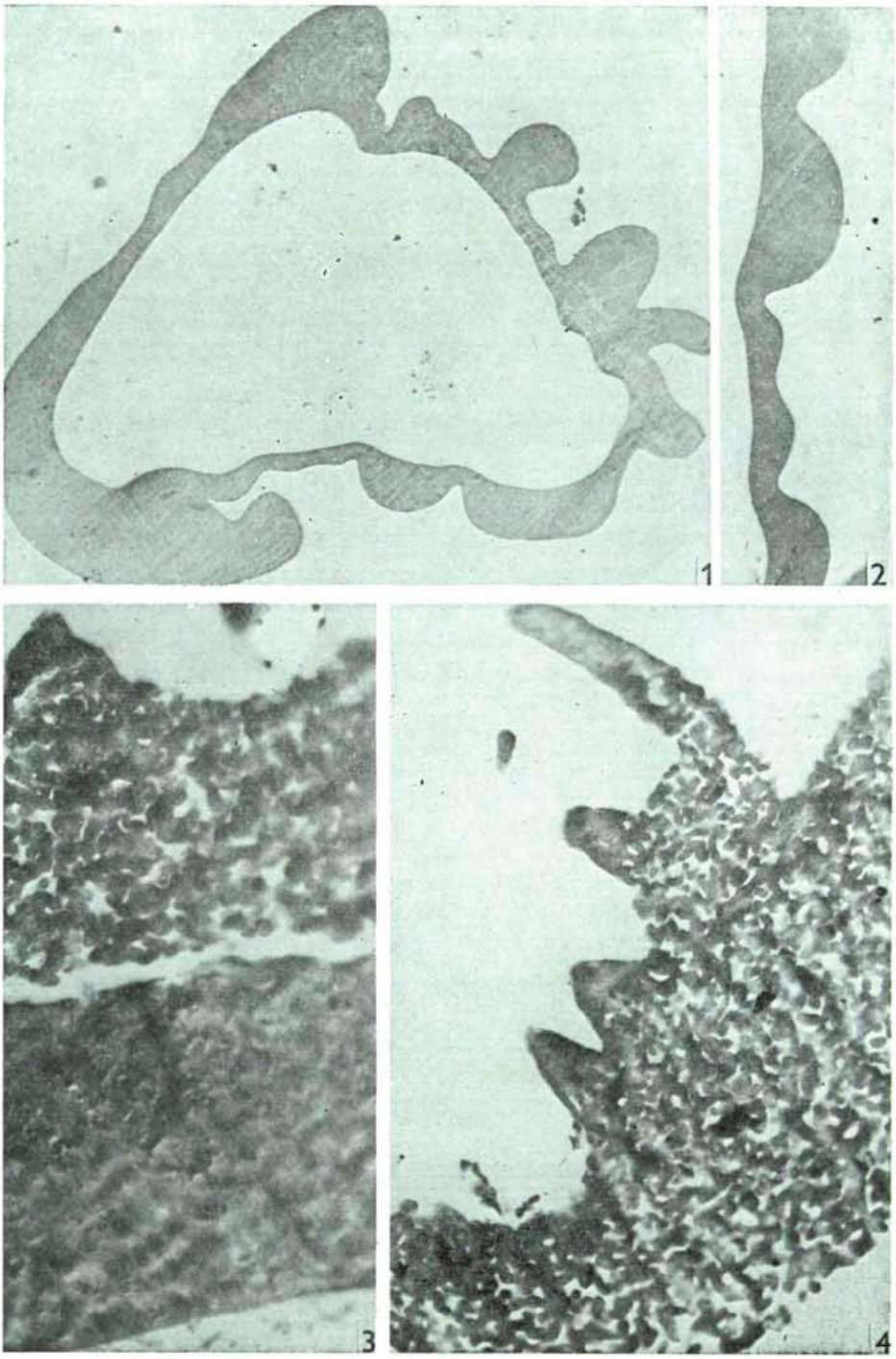


Table V
Ariadnaesporites, exospore and perispore cross section, x20000

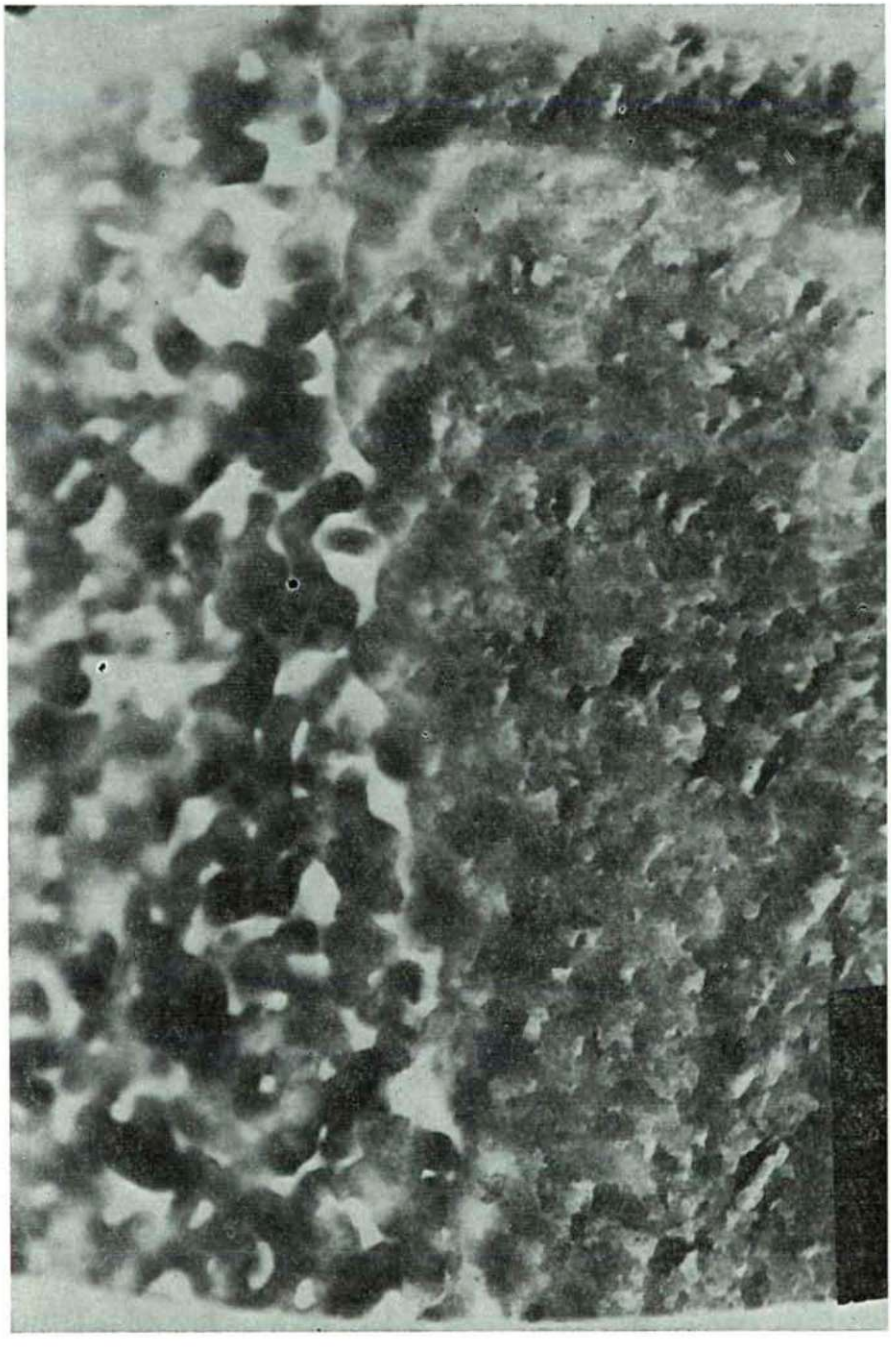
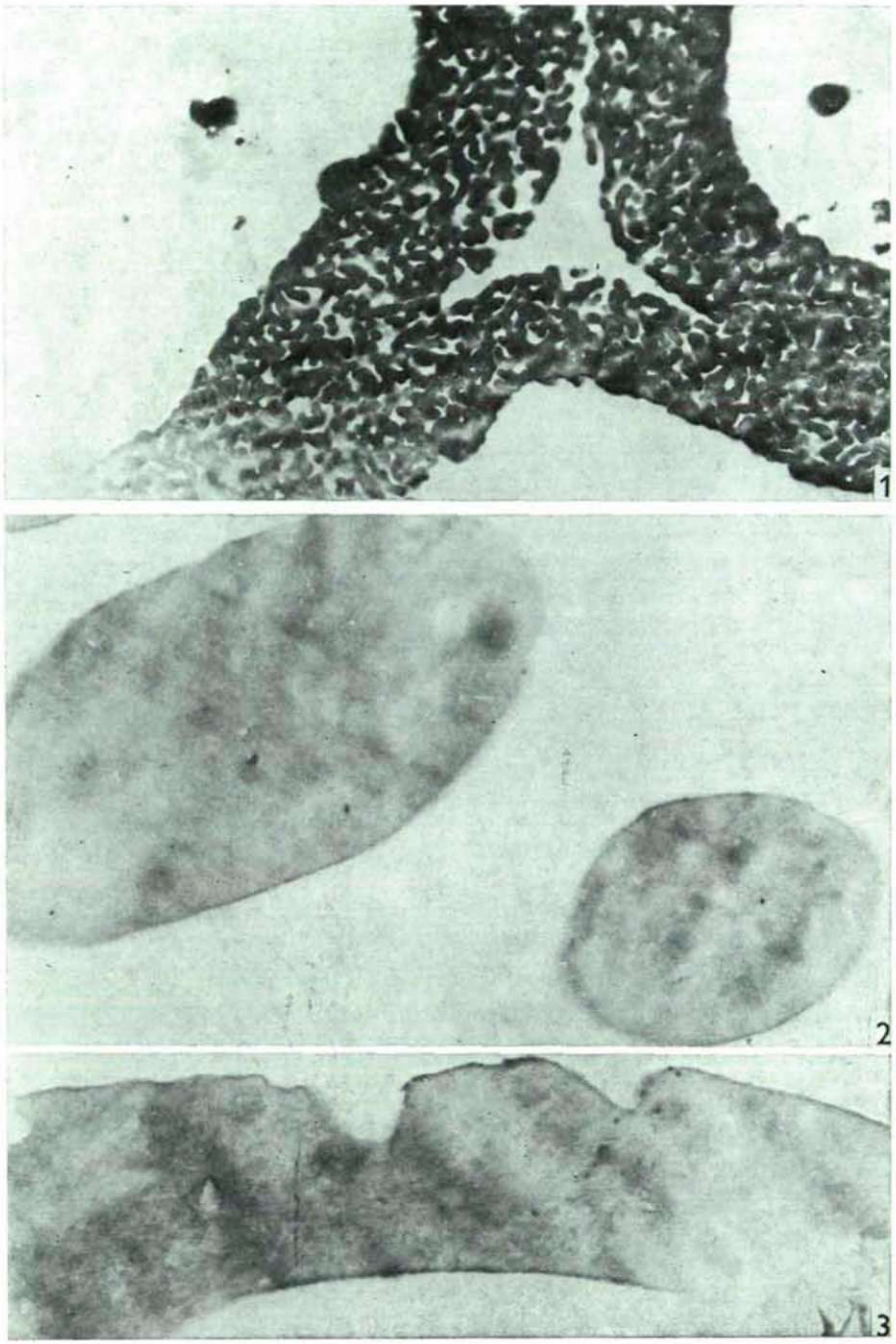


Table VI

1 *Ariadnaesporites* fsp XIII/3, trifolium cross section, x10000
2 *Ariadnaesporites* fsp XIII/3, section of elaters, x16000
3 *Microfoveolatosporis* fsp XIV/2, exospore cross section, x16000



mark nearly reach the inner border of the zone, r=4/5. The central body has verrucate/rugulate ornaments, the size of the ornamental elements is about 3—4 μm. Diameter is 45 μm.

TEM characters: The exospore, including cingulum (Table IV, 1) and the sculptured central body (Table IV, 2) are completely homogeneous

Fgenus: *Ariadnaesporites Potonié* 1956 emend. TSCHUDY 1966

1. *Ariadnaesporites* fsp XIII./3 (Table IV, 3, 4, Table V, Table VI, 1, 2)

Light microscopic characters: The exospore includes a global part, the perispore continues in a trifolium. Numerous 1.5—2 μm wide elaters spring from the later. The diameter is 120 μm.

TEM characters: On the inner wall of the exospore there are granules probably remains of the cytoplasma. No fine structure can be recognized on these fragments (Table IV, the lower part of picture 3). The exospore is inhomogeneous (Table IV, 3, Table V), although this structure may be the consequence of imperfect cutting. The border between the perispore and exospore is sharp (Table IV, 3, Table V). The perispore has an irregular form and a granular, spongy structure (Table IV. 3, 4, Table V). In contrast to this the elaters are completely homogeneous (Table IV, 4, Table VI, 2). The ultrastructure of the trifolium (Table VI, 1) is identical with that of the perispore.

Fgenus: *Microfoveolatosporis* W. KR. 1959

1. *Microfoveolatosporis* fsp XIV./2 (Table VI, 3)

Light microscopic characters: It is a monolete spore, the square mark does not reach the apicis of the spore, r=4/5. The spore wall is 1.5—2 μm thick with a microfoveolate sculpture of 0.5 μm diameter. The diameter is 55 μm.

TEM characters: The exospore is completely homogeneous. The foveae are only superficial hollows, generally reaching only the third part of the thickness of the wall.

Discussion

In the light microscopic description of fossile miospores (not microspores!) it is a constant characteristic that the wall consists of two equal layers or one of the layers is thicker than the other. In authors' first TEM investigations (KEDVES and PÁRDUTZ, 1973) on the basis of different electron affinity two very clearly defined lyaers were demonstrated on Eocenic *Leiotriletes* and *Toroisporis* spores. Less convincing was the demonstration of the presence of layers with different electron affinity on the wall of *Appendicisporites*. Authors' recent data about fgenus *Leiotriletes* shows something totally new. It was demonstrated that the wall is essentially unlayered. At the same time it was also demonstrated that cavities and channels occur only in the inner part of the spore wall and therefore, in consequence of altered refraction, the layer with cavities and/or channels may appear as an independent one.

It is unfamiliar that the diameter of the cavities and channels can have a taxonomical significance because according to the data till now the ultrastructure of the exine is less variable than the light microscopic morphology. The work of LUGARDON (1972. 1974) give a good picture of the ultrastructure of recent Pteropsida spore walls. So radial channels occur in the exospore of *Blechnum spicant, Lygodium japonicum, Gleichenia bancrostii, Cibotium glaucum, Cyathea medullaris, C. cooperi, Dennstaedtia bipinnata, Ceratopteris cornuta, Pteris longifolia, Cryptogramma crispa,, Adiantum capillus-veneris, Athyrium filixfemina, A. alpestre, Cystopteris fragilis, Scolopendrium vulgare, Polypodium serratum, Angiopteris hypoleuca, Marattia fraxinea, Osmunda*

regalis. Cavities occur in the exospore of *Gleichenia bancrostii, G. linearis, G. oceanica, Ophioglossum vulgatum, O. lusitanicum, Botrychium lunaria, Angiopteris hypoleuca, Marattia fraxinea, Osmunda regalis, Leptopteris fraseri*. It is worth mentioning that spore wall ultrastructures similar to the exospores of the fossilia investigated by authors were not found in the literature. It is just possible that Cretaceous spores which may be identified with recent genera on the basis of light mircoscopic investigations have a different ultrastructure and so differ from the recent genera.

More investigations are essential in the fgenus *Cicatricosisporites;* the completely homogeneous ultrastructure of the exospore gives food for thoughts. The same holds, and in an increased degree, in respect of the *Polypodiaceoisporites* fsp because in light microscope the spore wall showes several well defined layers. These are to be considered as refractional phenomena according to authors' present data.

At present detailed nomenclatural investigation of the fgenus *Ariadnaesporites* is not necessary; the taxonomic revision can be easily performed in the light of the descriptions of DINIZ (1967). Authors' TEM data can be compared with the results till now, differences appear only in minor details.

The ultrastructure of the spore wall of *Microfoveolatosporis* corresponds to that observed on *M. pseudodentatus* from the Eocene (KEDVES and PÁRDUTZ, 1973).

References

DINIZ, F. (1967): Spores à flagelles nouvelles pour le Crétacé du Portugal. — Pollen et Spores *9*, 569—577.

DINIZ, F. KEDVES, M. and SIMONCSICS, P. (1974/1977): Les sporomorphes principaux de sédiments crétacés de Vila Flor et de Carrajao, Portugal.-Com. Serv. Geol. Port. *58*, 161—178.

HILLS, L. V. (1967): Ariadnaesporites, Capulisporites or Caudaspora: A discussion. — Pollen et Spores *9*, 553—562.

KEDVES, M. (1978): Ultrastructure investigations into fossil Salviniaceae spores. — Acta Biol. Szeged, *24*, 19—22.

KEDVES, M. and HEGEDŰS, M. (1975): Pollen grains of the Interporopollenites fgen. from sediments of the Upper Cretaceous period in Portugal. — Acta Biol. Szeged. *21*, 43—62.

KEDVES, M. and PÁRDUTZ, Á. (1970): Études palynologiques des couches du Tertiaire inférieur de la Région Parisienne VI. Ultrastructure de quelques pollens d'Angiospermes de l'Ecoène inférieur (Sparnacien). — Pollen et Spores *12*, 553—575.

KEDVES, M. and PÁRDUTZ, Á. (1973): Ultrastructure examination of fossil Pteridophyta spores and Gymnospermatophyta pollens. — Acta Bot. Acad. Sci. Hung. *18*, 304—313.

KEDVES, M. et PITTAU, P. (1979): Contribution à la connaissance des pollens des Normapolles du "groupe papilloide" du Crétacé supérieur du Portugal. — Pollen et Spores *21*, 169—209.

KEMPF, E. K. (1969a): Elektronenmikroskopie der Sporodermis von käinozoischen Megasporen der Wasserfarn-Gattung Azolla. — Paläont. Z. *43*, 95—108.

KEMPF, E. K. (1969b): Elektronenmikroskopie der Megasporen von Azolla tegeliensis aus dem Altpleistozän der Niederlande. — Palaeontographica B, *128*, 167—179.

KEMPF, E. K. (1971): Elektronenmikroskopie der Sporodermis von Mega- und Mikrosporen der Pteridophyten-Gattung Salvinia aus dem Tertiär und Quartär Deutschlands. Palaeontographica B, *136*, 47—70.

KRUTZSCH, W. (1959): Mikropaläontologische (sporenpaläontologische) Untersuchungen in der Braunkohle des Geiseltales. — Geologie 8, BH *21/22*, 1—425.

LUGARDON, B. (1972): La structure fine de l'exospore et de la perispore des Filicinées isosporées I — Généralités. Eusporangiées et Osmundales. — Pollen et Spores *14*, 227—261.

LUGARDON, B. (1974): La structure fine de l'exospore et de la périspore des Filicinées isosporées II. Filicales. Commentaires. — Pollen et Spores *16*, 161—226.
PETTITT, J. M. (1966): Exine structure in some fossil and recent spores as revealed by light and electron microscopy. — Bull. B. M. (N. H.) Geol. *13*, 223—257.
TRYON, A. F. and LUGARDON, B. (1978): Wall structure and mineral content in Selaginella spores. — Pollen et Spores *20*, 315—340.

Address of the authors:
Dr. M KEDVES
Department of Botany, A.J. University,
H-6701 Szeged P.O.Box 428.
Dr. Á.PÁRDUTZ
Institute of Biophysics, Biological
Center of the Hungarian Academy
of Sciences, Szeged,
Hungary

Acta Biologica Szeged. *27* (1—4), pp. 117—126 (1981)

EFFECT OF SHORT PERIODS OF LIGHT AND DARKNESS ON THE HISTOLOGICAL STRUCTURE OF BEAN, MUSTARD AND PEA

I. Maróti, Katalin Margóczi, M. Y., Al-Subai
Erzsébet Fülöp, Edit Takács and Erzsébet Mihalik

Department of Botany, Attila József University, Szeged
(Received September 16, 1980)

Summary

Dry matter production and histological structure of bean, mustard and pea grown under a short-period (30—15 min) and under a 16—8 hour period alterations of light and darkness were compared. The short-period treatment caused a considerable diminution of dry matter of the bean, a slight diminution of that of the mustard while in the case of pea hardly any change occured. The leaves of bean and mustard grown under the short-period treatment became thinner and larger than those in 16—8 hour period; in first line the reduction of mezophyll can be attributed to the decrease of spongy parenchyma. The stems of the bean were thinner, the ration of phloem and xylem was lower, that of the pith higher. In the stems of the mustard the opposite tendency was observed.

Introduction

It was first observed by Brown and Escombe (1905) that photosynthetic effectivity in higher plants can be highly (more than 100 per cent) increased by photoperiodic treatment. Subsequently Emerson and Arnold (1935) established that exploitation of light energy per unit in the photosynthesis of Chlorella is very high when very short (about 10 μs) flashings are interrupted by longer (about 10 ms) dark periods. The striking importance of very short (0.01—100 s) light-dark periods on growth and CO_2 assimilation was confirmed by Rabinowitch (1956), Wittingham and Brown (1958), Wittingham and Bishop (1961) on algae and by Pollard (1969) on *Populus grandidentata.*

The first detailed description of the effect of longer light-dark periods on growth and flowering of higher plants are found in the classical works of Garner and Allard (1920, 1927, 1931). They changed the length of light and darkness from 5 s to 12 h; using several species it was established that

a) Each species requires different periods of light and darkness for vegetative growth and flowering respectively: plants requiering long phoroperiods, plants requiering short periods and plants indifferent in this respect can be distinguished.

b) In enhancing growth two maxima were observed: 5 s and 12 h. Later Bonds (1955) observed a third maximum in the case of tomato at 4—4 h and in the case of Xanthium at 1—1 h period.

c) In general, the 1—15 min periods considerably inhibit growth.

Gregory and Pearse (1937) observed that a short periods cause partial closing

of stomata of *Pelargonium zonale*. The slit between the guard cells is smallest at about a 1 minute period. The same was observed on the stomata of *Cucumis sativus* by PORTHSMOUTH (1937). Parallel to the decrease of the slit on the 22 day dry matters weight (a single cucumber plant) was the fourth area of the leaves the half as compared to plants grown under a 12—12 h period. Considerable reduction in dry matter, height and leave-area under 1—15 min periods was established also by BEHREND (1950), BONDE (1955), FOGG (1968), RAJAN et al. (1971).

Effect of inequal periodicity in light and darkness was investigated by HORVÁTH and MIHALIK (1977, 1978), HORVÁTH, TAKÁCS and MIHALIK (1979). 4 hours light and 2 hours dark cycles caused a 20 per cent increase, 2 hours light and 1 hour dark a 20 per cent decrease in dry matter as compared to a control of 16—8 h period.

According to above data the different light-dark cycles has great importance in the utilization of light energy. However, there are no data (except ALSUBAI and HORVÁTH 1980) about the effect of light-dark cycles on histological structure. To supplement this deficiency is the aim of this paper.

Materials and Methods

The investigated plants were: bean, *Phaseolus vulgaris* L. cv. Cheroque; pea, *Pisum sativum* L. cv. Kelvedons wonder; and mustard, *Sinapis alba* L.

In the phytotron (HORVÁTH, 1972) the plants got an irradiation of 35 Wm^{-2} in the 400—700 nm interval from light tubes F_{29}. The light-dark periods applicated were 30—15 min and 16—8 h respectively.

In the clima-boxes the temperature of air was 22—25 °C, the relative humuidity 50—75 per cent, the CO_2 concentration 0.03 per cent.

The plants were grown on a mixture of perlit and san 1:1 (volume) in Knop solution for six weeks. Water capacity of the substrate was daily adjusted to 70 per cent with distilled water.

The plants were harvested and investigated after six weeks growth. Dry weight was measured after fixation at 105 °C and drying at 70 °C.

For histological investigation in the case of bean the primordial and the first tripartite leaves and the stem between them, in the case of mustard and pea the fourth and fifth leaves and the internode beneath them were used. The epidermis was investigated in macerated preparates. Leaves and stems were cut after embedding in colloidine. The tissues of leaves were stained with Ehrlich's acidic haematoxyline, the stem cross sections with malachit green vesuvin double staining procedure.

In the leaves the number of epidermis cells and stomata per mm^2 and the thickness of the mesophyll and the palisade parenchyma were established. Cross sections of stems were drawned on paper with the aid of a projecting microscope; the ratio of the different histological regions was established by weighing the cut-out paper scraps.

Results

Changes in morphological characteristics

The short period (30—15 min) cycle (as compared to the 16—8 h cycle) differently influences the different plants. The bean's leave appears sooner, bean and mustard become higher, the area of the leaves become larger (Table 1). The leave of the pea reacted only slightly on the treatment.

Accumulation of dry matter and its distribution in the organs

This also shows differences in the different plants. As the result of short-period treatment dry weight is considerably decreased in bean, a little did it in mustard and

Table 1. Effect of the lenght of light-dark cycles on the number of leaves, area of leaves and height of plants.

	Bean		Mustard		Pea	
	1/2—1/4 (h)	16—8 (h)	1/2—1/4 (h)	16—8 (h)	1/2—1/4 (h)	16—8 (h)
Number of leaves per plant	6.6	4.6	11.5	12.0	10.6	11.0
Area of leaves cm^2 per plant	321.6	285.3	118.9	89.7	137.3	136.2
Height of plant cm	28.9	22.1	63.3	52.9	25.7	26.8

hardly changed in pea. In the case of pea a slight increase in dry matter might be attributed to the flowering enhancing effect of the short periods (Table 2).

Changes of thickness of the mesophyll

Short periods diminished in all the three plants the thickness of leaves. This change is the smallest in pea, in bean it attains 20—30 per cent. Decrease in thickness can be attributed in first line to the diminishing of the spongy parenchyma (Table 3). Absolute thickness of the palisade parenchyma changed only slightly but its relative share in the mesophyll increased (Plate I).

Table 2. Effect of the length of light-dark cycles on dry matter (mg) one plant

	Bean		Mustard		Pea	
	1/2—1/4 (h)	16—8 (h)	1/2—1/4 (h)	16—8 (h)	1/2—1/4 (h)	16—8 (h)
Root	205.5	390	228	252	219	246.5
Stem	390	580	712	734	323	323
Leave	388	664	312	353	368	351
Fruit	25	117	—	—	478	322
Total	1009	1751	1251.5	1390	1388	1242

Table 3. Effect of the length of light-dark cycles on the thickness of mesophyll

	Bean (primordial leave)		Bean (tripartite leave)		Mustard		Pea	
	1/2—1/4 (h)	16—8 (h)	1/2—1/4 (h)	16—8 (h)	1/2—1/4 (h)	16—8 (h)	1/2—1/4 (h)	16—8 (h)
Thickness of mesophyll (μ)	102.5	138	90	113.5	100	121	146	148
Thickness of Spongy parenchyma (μ)	58.4	86.9	45.9	59.0	53	79.9	87.6	94.7

Changes in the structure of the epidermis

This characteristic was differently influenced by 0.5—0.25 hour light-dark cycle in the different plants and depended of the position of the leaves as well. The number of epidermis cells and stomata per unit area was increased on bean (primordial leave) and mustard and decreased on bean (tripartite leave) and pea. The changes in the dimension of epidermis cells (at 3rd and 5th leaves) is, in general, greater on the adaxial than on the abaxial surface (Table 4, Plate II).

Table 4. Effect of the length of light-dark cycles on the epidermis of leaves

	Bean (primordial leave)		Bean (tripartite leave)		Mustard		Pea	
	1/2—1/4	16—8	1/2—1/4	16—8	1/2—1/4	16—8	1/2—1/4	16—8
Adaxial surface number of stomata per mm²	29.4	23.9	—	—	189	130	129	145
Adaxial surface number of epidermis cells per mm²	424	418	389	496	872	699	438	481
Abaxial surface number of stomata per mm²	264	219	198	237	331	257	157	175
Abaxial surface number of epidermis cells per mm²	950	841	797	992	875	756	352	390

Histological features of the stem

The stem of mustard and that of bean were more elongated under the short-period treatment. The elongated stem is thinner in case of bean and thicker in case of mustard. Short-period treatment decreased the relative participation of sclerenchyme, cortex, phloem and xylem and increased that of pith (Table 5, Plate III).

In case of mustard increase of phloem and xylem was dominant, the ration of sclerenchyme and pith decreased (Plates II and III). In case of pea, being rather unsensitive to the treatment, no significant differences were established between the two cycles (Table 5).

Plate I

1. Bean *(Phaseolus vulgaris)*, cross section of tripartite leave; light-dark cycle 16—8 h (x230)
2. Bean, cross section of tripartite leave; light-dark cycle 0.5—0.25 h (x230)
3. Pea *(Pisum sativum)*, cross section of leave; light-dark cycle 16—8 h (x230)
4. Pea, cross section of leave; light-dark cycle 0.5—0.25 h (x230)
5. Mustard *(Sinapis alba)*, cross section of leave; light-dark cycle 16—8 h (x230)
6. Mustard, cross section of leave; light-dark cycle 0.5—0.25 h (x230)

Plate I

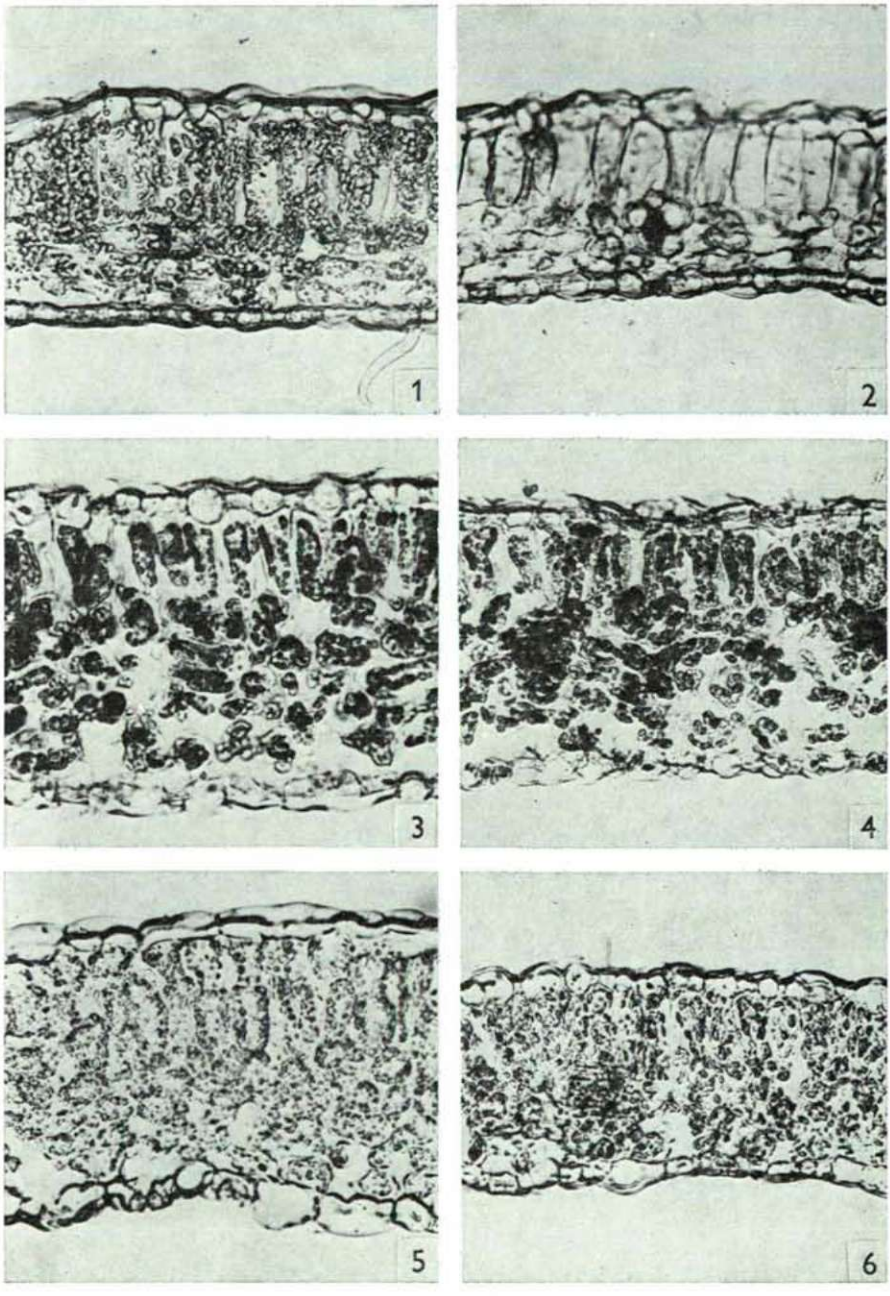


Table 5. Effect of the length of light-dark cycles on the proportion of the different tissues

	Bean		Mustard		Pea	
	1/2—1/4	16—8	1/2—1/4	16—8	1/2—1/4	16—8
Area of the stem cross section mm²	7.1	9.4	12.1	10.0	2.7	2.8
Cortex per cent	19.6	21.2	20.4	16.8	61.8	55.1
Sclerenchyma per cent	3.4	3.6	1.1	1.5	5.2	4.2
Phloem per cent	9.1	11.3	3.2	2.9	7.5	8.9
Xylem per cent	13.9	15.2	17.0	15.2	13.2	12.5
Pith per cent	54.0	47.2	58.4	63.8	11.8	13.0

Discussion

Authors' investigations demonstrated the essential significance of the different light-dark periods on growth, dry matter accumulation and histological structure of the plants. It was also established, in accordance with GARNER and ALLARD (1931), GREGORY and PEARSE (1937), PORTSMOUTH (1937), BONDE (1955) etc., that different plants react differently on cyclic treatments. In authors' experiments the 30—15 min periods influenced most sensitively the bean, less the mustard and least the pea.

GARNER and ALLARD (1931) explained different reactivity of plants by their short-day, long-day properties and their indifferency in this respect. But some of the data of GARNER and ALLARD can hardly be interpreted with the photoperiodic demand. E.g. the long-day plants *Rudbeckia bicolor* and *Delphinium ajacis* flower the quickest and accumulate maximal dry matter at 5—5 s cycle. On the other hand their experiences showd that there are cycles with similar effect on different plants: the short-day plant *Cosmos sulphureus* and the indifferent *Fagopyrum vulgare* shows similar growth and dry matter production at 5—5 s, 1—1 min and 12—12 h periods.

General decreasing effect on dry matter accumulation of the 1—15 min light-dark cycles was observed also by GREGORY and PEARSE (1937), PORTSMOUTH (1937), BONDE (1955), FOGG (1968), RAJAN et al. (1971) etc.

It seems, according to literary data and to authors' results, that the "favourable" cycles occur in the intervals of 1—15 s, 1—4 h and 12—16 h respectively.

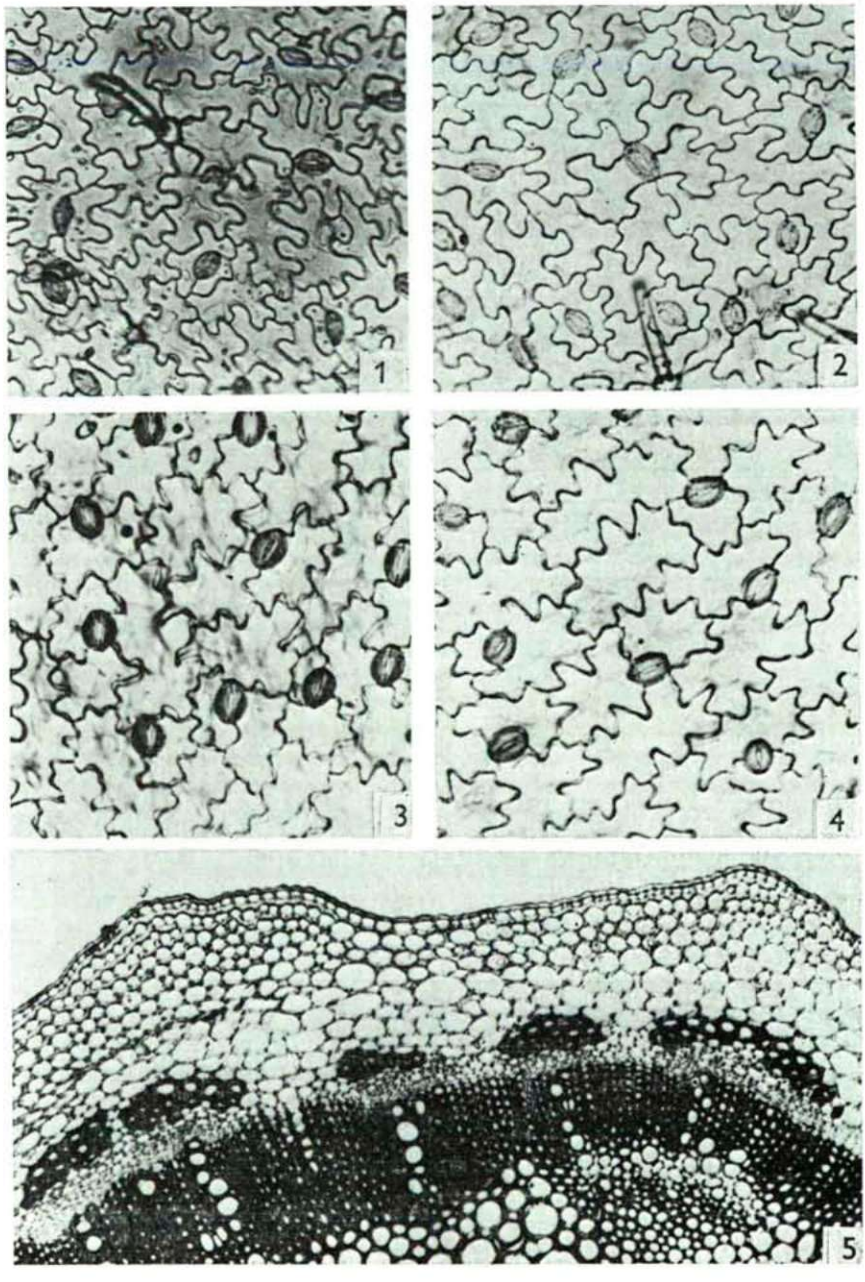
Former investigations of TAKÁCS and HORVÁTH (unpublished) showed that the excellent dry matter production of bean (cv. Aranka) at 4—2 h cycles considerably diminished at the 2—1h and 1—0.5 h cycles (Fig. 1).

As it could be expected, in recent experiments at 0.5—0.25 h periods the thinnest leaves, the lowest dry matter accumulation and the greater histological changes were observed in the case of bean.

Plate II

1. Bean, tripartite leave, abaxial epidermis; light-dark cycle 16—8 h (x230)
2. Bean, tripartite leave, abaxial epidermis:, light-dark cycle 0.5—0.25 h (x230)
3. Pea, adaxial epidermis; light-dark cycle 16—8 h (x230)
4. Pea, adaxial epidermis; light-dark cycle 0.5—0.25 h (x230)
5. Mustard, stem cross section; light-dark cycle 16—8 h (x100)

Plate II



It may be supposed that one of the favourable cycles of the pea is about one hour. On the other hand the unfavourable effect of a cycle about 1—15 min were demonstrated on several algae and higher plants, although there might exist plants (pea?) which are insensitive in this respect.

The mechanism of the effect of light-dark cycles, especially of short (1—15 min) cycles is unknown. On the basis of investigations about changes in pigment caused by short cycles (MARÓTI et al. 1980) it may be supposed that the light-dark cycles exert their activity through the light-dependent electron and proton transport. The specific differences are correlated with the membraneous systems of the chloroplasts.

The great variability of the spongy parenchyma and its reduction are elicited by short-period cycles (Plate III, Fig. 1). It is supposed (MARÓTI, 1976) that in the spongy parenchyme the noncyclic while in the palisade parechyme the cyclic phosphorilation predominate.

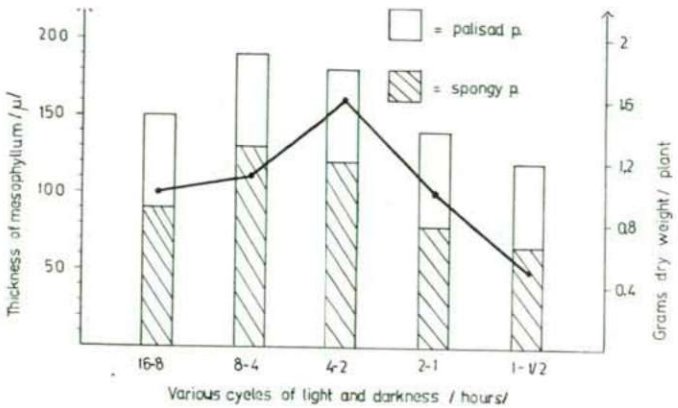


Fig. 1. Effect of the length of light-dark cycles on the ratio of spongy-parenchyma and palisade parenchyma and on the accumulation of dry matter in bean (cv. Aranka).

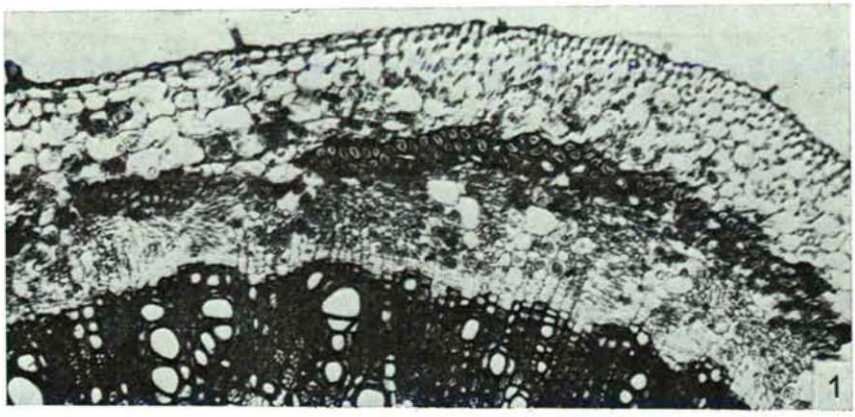
An important role can be attributed to the spongy parenchyma in the production of the primary and intermediary products of the photochemical reaction. The great variability of the spongy parenchyma makes possible the adaptation of the plants to different light-conditions.

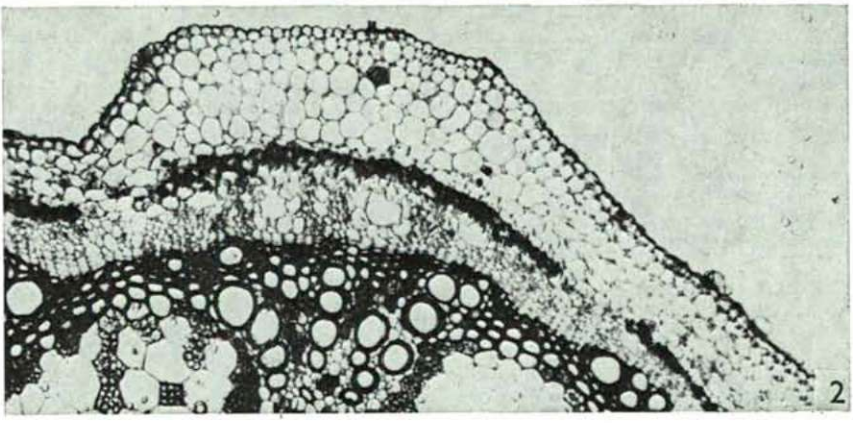
The opposite reaction of the histological struture of the stem in the bean and in the mustard may be contributed to the tendency of leave producing in the dwarf bean and to the tendency of stem producing in the mustard. The mechanism regulating the ratio of the different tissues in organs is unknown.

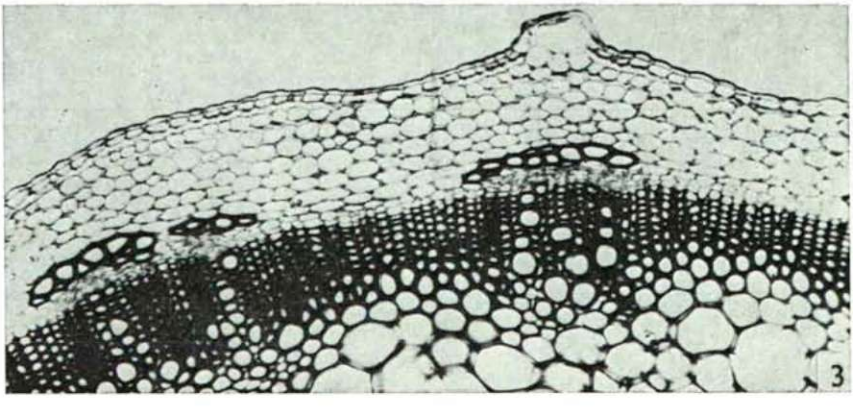
Plate III

1. Bean, stem cross section; light-dark cycle 16—8 h (x100)
2. Bean, stem cross section; light-dark cycle 0.5—0.25 h (x100)
3. Mustard, stem cross section; light-dark cycle 0.0—0.25 h (x100)

Plate III







References

ALSUBAI, M. Y. and HORVÁTH, I. (1980): The effect of alternating periods of light and darkness on the tissue of *Phaseolus vulgaris* L. — Acta Biol. Szeged *26*, 41—50.

BEHREND, H. (1950): Notiz über die Wirkung intermittierenden Lichtes auf das Wachtum der Diatomeen. — Arch. Mikrobiol. *14*, 531—3.

BONDE, E. K. (1955): The effect of various cycles of light and darkness on the growth of tomato and cocklebur plants. Physiol. Plant. *8*, 913—923.

BROWN, H. T. ans ESCOMBE, F. (1905): Researches of some of the physiological processes of green leaves, with special reference to the interchange of energy between the leaf and its surroundings. — Proc. Roy. Soc. Ser. B. Biol. Sci. *76*, 29—111.

EMERSON, R. and ARNOLD, W. (1932): A separation of the reactions in the photosynthesis by means of intermittent light. — J. Gen. Physiol. *15*, 391—420.

FOGG, G. E. (1968): Photosynthesis. The English Univesrity Press. Pp. 116.

GARNER, W. W. and ALLARD, H. A. (1920): Effect of the relative length of day and night and other factors of the environment on growth and reproduction in plants. — J. Agric. Res. *18*, 553—606.

GARNER, W. W. and ALLARD, H. A. (1927): Effect of short alternating periods of light and darkness on plant growth. — Science (n.s.) *66*, 40—42.

GARNER, W. W. and ALLARD, H. A. (1931): Effect of abnormally long and short alternations of light and darkness on growth and development of plant. — J. Agric. Res. *42*, 629—53.

GREGORY, F. G. and PEARSE, H. L. (1937): The effect on the behaviour of stomata of alternating periods of light and darkness of short duration. — Ann. Bot. *1*, 3—10.

HORVÁTH, I. and MIHALIK, E. (1977): A megvilágítás ritmusosságának hatása a szárazanyag felhalmozódására. — Bot. Közlem. *64*, 121—124.

HORVÁTH, I. and MIHALIK, E. (1978): Változó idejű ritmusos megvilágítás hatása a mustár szervesanyag produkciójára (Effect of alternating periods of light and darkness on the dry-matter production of the *Sinapis alba*). — Bot. Közlem. *65*, 181—186.

HORVÁTH, I., TAKÁCS, E. and MIHALIK, E. (1979): Effect of the intensity of illumination on the dry-matter production and tissue structure of the *Capsicum* species. — Acta Biol. Szeged. *25*, 71—84.

MARÓTI, I. (1976): Photosynthetical pigments in the spongy and palisade parenchymas and the alternative ways of photosynthesis. — Acta Biol. Szeged. *22*, 7—14.

MARÓTI I., PATAKY SZ., MIHALIK E., FÜLÖP E. and MARGÓCZI K. (1980): A rövid tartamú fény-sötét ciklusok hatása a klorofillok és karotinoidok mennyiségére) Effect of short alternating periods of light adn darkness on content of chlorophylls and carotenoids. (In press).

POLLARD, D. F. W. (1970): The effect of rapidly changing light on the rate of photosynthesis in largetooth aspen *(Populus grandidentata)*. — Can. J. Bot. *48*, 823—829.

PORTSMOUTH, G. B. (1937): The effect of alternate periods of light and darkness of short duration on the growth of the cucumber. — Ann. Bot. *1*, 175—89.

RABINOWITCH, E. I. (1956): Photosynthesis and related processes. *11*, Part 2. Interscience, New York. Pp. 1313—1484.

RAJAN, A. K., BETTERIDGE, B. and BLACKAMN, G. E. (1971): Changes in the growth of *Salvinia natans* induced by cycles of light and darkness of widely different duration. — Ann. Bot. *35*, 597—604.

WHITTINGHAM, C. P. and BISHOP, P. M. (1961): Thermal reaction between two light reactions in photosynthesis. — Nature, Lond. *192*, 426—7.

WHITTINGHAM, C. P. and BROWN, A. H. (1958): Oxygen evolution from algae illuminated by short and long flashes of light. — J. Exp. Bot. *9*, 311—19.

Address of the authors:
Dr. I. MARÓTI
KATALIN MARGÓCZI
M. Y. AL—SUBAI
ERZSÉBET FÜLÖP
DR. EDIT TAKÁCS
DR. ERZSÉBET MIHALIK
Department of Botany A. J. University
H-6701 Szeged, P.O. Box 428. Hungary

Acta Biologica Szeged. 27 (1—4), pp. 127—137 (1981)

DORMANCY IN FRUITS OF TILIA PLATYPHYLLOS SCOP. V. POSSIBLE ROLE OF CHILLING STRATIFICATION IN BREAKING DORMANCY

MÁRIA NAGY, SZERÉN PATAKY and ÁGNES KÉRI

Department of Plant Physiology and Department of Botany, Attila József University, Szeged

(Received September 5, 1980)

Abstract

The sizes, germinative abilities and growth capabilities of embryos excised from lime seeds stratified in a chilled and warm state, respectively, were compared. Though the embryos could grow both during the warm and the chilled stratification, the elongation of the radicle proved to be more definite during chilled stratification. Embryos excised from seeds stratified in chilled state germinated quicker and grew more intensively than the embryos excised from seeds stratified in warm state. Chilled stratification plays a role also in the weakening of tissues surrounding the embryo.

Introduction

Lime seeds require for the breaking of their dormancy a chilled stratification for 150—180 days. Similarly to most seeds requiring stratification the decrease of the amount of inhibitors and the increase of the amount of endogenous gibberellin-like substances during stratification can be observed also in the case of lime seeds (SZALAI and NAGY, 1974; NAGY, 1980). However, stratification cannot be replaced by exogenous gibberellic acid, only the lenght of the stratification period can be shortened (NAGY and SZALAI, 1973). A further reduction of the stratification period is possible by the combined application of gibberellic acid and indole-acetic acid (IAA), (NAGY, 1976), which indicates that though these hormones may play an important role in the breaking of dormancy, during the stratification besides the rise of the level of endogenous hormones also other alterations important from the aspect of the breaking of dormancy take place.

On the effect of a hormonal stimulus arriving from the embryo a change may occur in the activity of metabolism, including the decomposition of the stored nutrients, ensuring in this way the nutrient supply of the embryo. Owing to the gluconeogenesis the water potential of the embryo will be more negative and thus it may represent a greater force against the surrounding tissues whose mechanical resistance remains unchanged. During the stratification also the mechanical resistance of the tissues surrounding the embryo may change or both processes of different direction may contribute to the breaking of dormancy.

In the course of our study into the changes occurring during stratification the following problems were investigated:

— observability of embryonal growth during stratification,
— existence of a difference in growth intensity between seedlings developed from embryos excised at various periods of stratification, and
— effect of the mechanical resistance of the surrounding tissues on the dormancy of the embryo.

Materials and Methods

Material of examination: Our investigations were carried out with fruits of Tilia platyphyllos Scop. obtained from the Forestry of County Csongrád.

Stratification and excision of embryos: After the removal of the pericarp the seeds were scarified with sulphuric acid then stratified in culture pots containing washed sand wetted to 80% of the full water capacity. Stratification was carried out in a refrigerator at 4—5°C and in a thermostat at 25°C, respectively. At various periods of stratification the seeds were disinfected with bromine water then the embryos were excised and kept in a Petri dish under semisterile conditions on filter paper wetted with White nutrient (WHITE, 1943) at a daily 16-hour illumination of 10 000 Lux, at a day-time temperature of 25°C and at a night temperature of 20°C.

Measurement of clorophyll content: the chlorophyll content of the leaves of the seedlings was determined by photometry, using the method of WINTERMANS and MOTS (1965).

Treatment of seeds with exogenous pectinase and cellulase

Also the seed-coat was removed from a part of seeds disinfected with bromine water and they were treated for 7 days with a 1% cellulase preparation (Fluka) prepared by a phosphate buffer of pH 5.0. Another part of the seeds was treated with a 1% pectinase preparation (Fluka) prepared by a phosphate buffer of pH 4.0 whereas a third part of the seeds similarly for 7 days with a preparation of 1% cellulase+1% pectinase.

During the treatment period the seeds were incubated at 25 °C, on exchanging each day twice the enzyme preparation. After the 7-day treatments with the enzyme preparation a part of the seeds was placed in a thermostat of 25 °C and another part in a refrigerator. In both cases also the influence of a treatment with 3.10^{-4} m GA_3 or with 3.10^{-4} m $GA_3 + 3.10^{-4}$ m IAA on the germination of seeds after the exogenous enzyme treatment was investigated (NAGY, 1976). The result was evaluated after the elapse of a month.

Histological investigations. After the removal of the seed-coat the seeds were fixed by the Juel-type fixina agent (SÁRKÁNY and SZALAI, 1968) and cross and longitudinal cuttings were prepared by embedment in celloidin. Hematoxylin of Ehrlich type was used for the staining of the preparations.

Results and discussion

Effect of chilled and warm stratification on the growth of embryos present in intact seeds

Since the embryos removed from dormant lime seeds are geminating quickly in a wet environment without any pretreatment and no signs of any morphological abnormity can be observed on the developing seedlings whereas at the same time a chilled stratification is required for the breaking of dormancy of the intact seed, it appeared to be of interest to examine whether a difference exists between the size and the growth intensity of embryos removed from warm stratified and chilled stratified seeds.

As shown by Fig. 1, the embryos are growing both during warm stratification and during chilled stratification. Though at the beginning the warm stratification appears to be more favourable for the growth of embryos, the elongation of the radicle

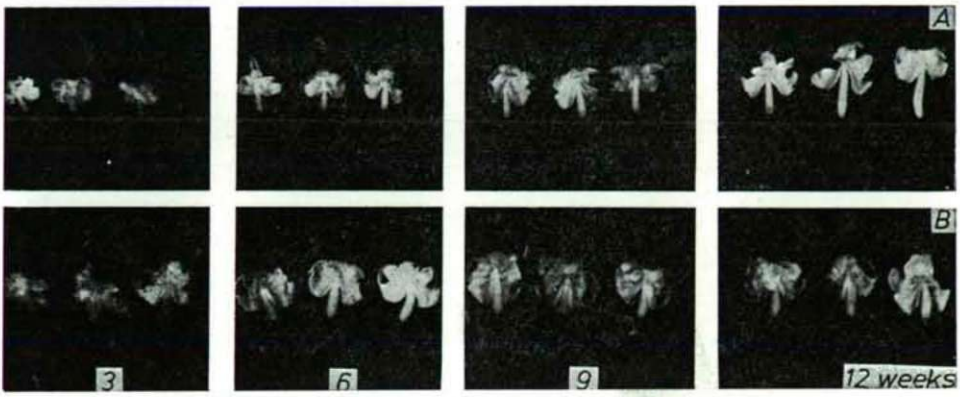


Fig. 1. Embryos excised from seeds chilled stratified (A) and warm stratified (B) for various periods.

is more intensive during chilled stratification. The difference in the size of embryos at the various periods of stratification is due not only to water uptake because also the dry matter content of the embryos increases with the length of stratification periods, indicating that an actual growth takes place (Table 1).

Table 1. Fresh mass and dry matter content of embryos excised from seeds stratified for various periods, referred to 100 embryos

Stratification period, weeks	5 °C		25 °C	
	Fresh mass, g	Dry mass, g	Fresh mass, g	Dry mass, g
3	0.8442	0.3862	0.8585	0.3855
6	1.2132	0.4341	1.1971	0.3909
9	1.6972	0.5963	1.4039	0.4876
12	1.8584	0.6616	1.6308	0.6011

The more vigorous development of embryos stratified at 5 °C is proved also by the histological investigations (Fig. 2). Striking differences appear in the thickness of the cotyledons and cell-walls on the effect of treatments at both applied temperatures. The more favourable effect of stratification at 5 °C manifests itself also at the shoot apex in the size and in the differentiated nature of the shoot apex. However, this difference is not as definite as in case of the cotyledones.

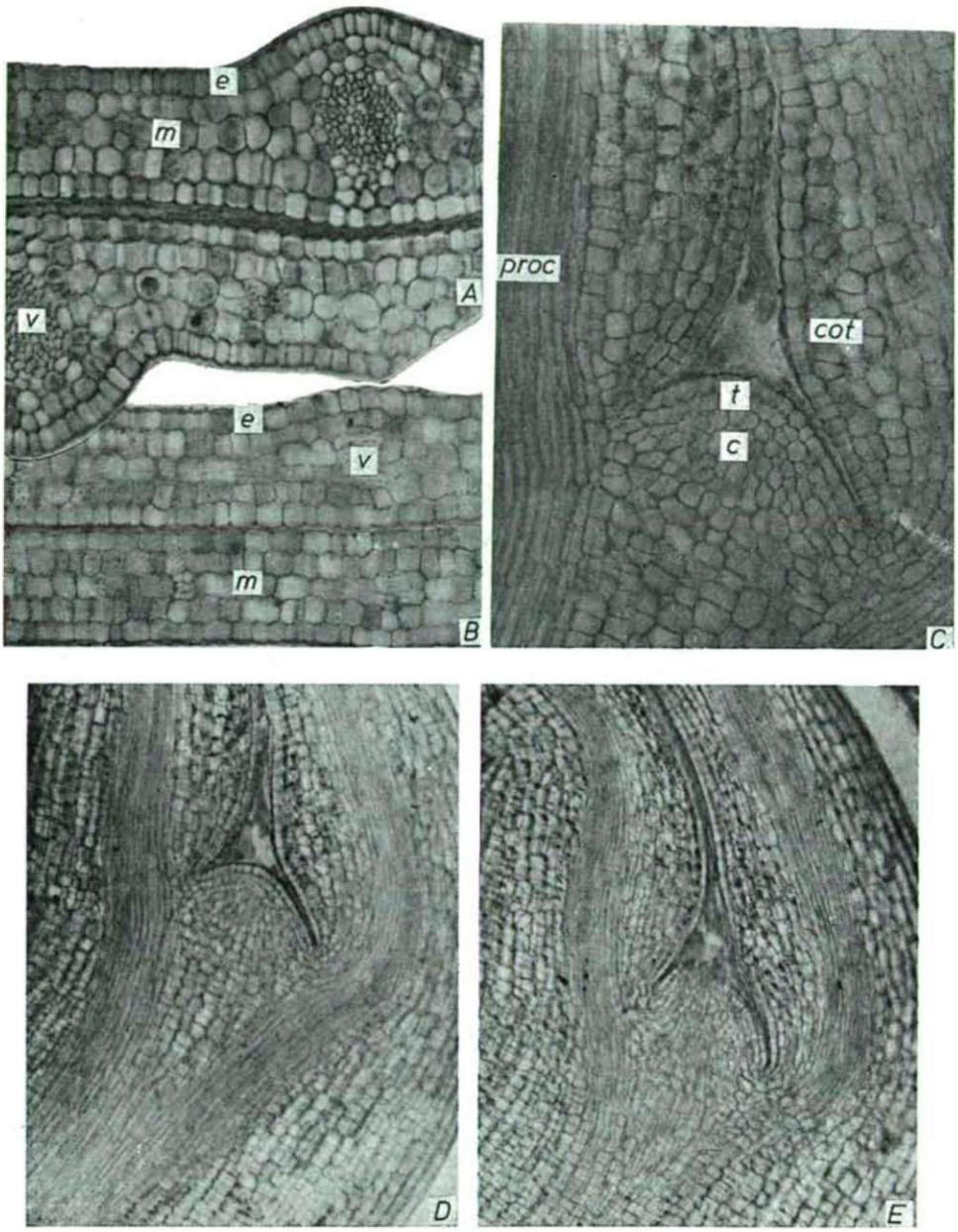


Fig. 2. State of development of embryos stratified for two months at various temperatures
A: cross section of the cotyledon of an embryo stratified at 5 °C. e=epidermis, m=mesophyllum, v=vascular tissue; x270
B: cross section of the cotyledon of an embryo stratified at 25 °C. x270
C—D: median longitudinal section of the shoot apex of an embryo stratified at 5 °C. c=corpus, cot=cotyledon, proc=procambium, t=tunica. C=x270, D=x140.
E: median longitudinal section of the shoot apex of an embryo stratified at 25 °C, x140

Growth intensity of embryos excised at various periods of stratification

Embryos excised at various periods of stratification differ from each other in the speed of germination (Fig. 3) (in the case of excised embryos the first geotropic curvature of the radicle is considered as germination). The longer was the period of chilled stratification, the higher is the percentage of germination in the first 24 hours. A parti-

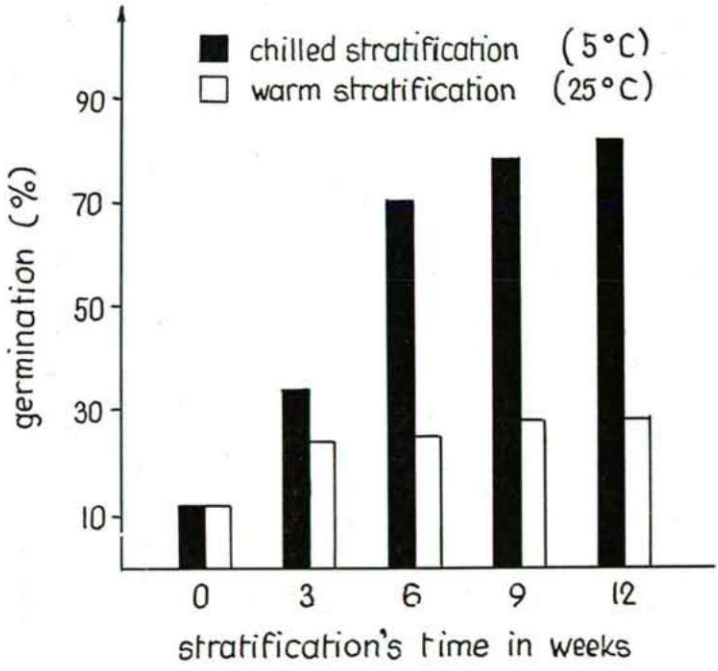


Fig. 3. Germination of embryos stratified for various periods, observed 24 hours after excision

cularly great change is observable after six weeks of chilled stratification. Embryos warm stratified for various periods are germinating much slower and hardly differ from each other from the aspect of their vigour of germination.

The growth activity of embryos excised at various periods of stratification is presented in Fig. 4. where the size of seedlings is shown at the seventh day after excision, expressed as percentages of the non-stratified controls.

Similarly to the results of germination tests, the growth intensity of embryos warm stratified for various periods is very similar but even in case of a stratification of the shortest duration higher than that of the non-stratified control.

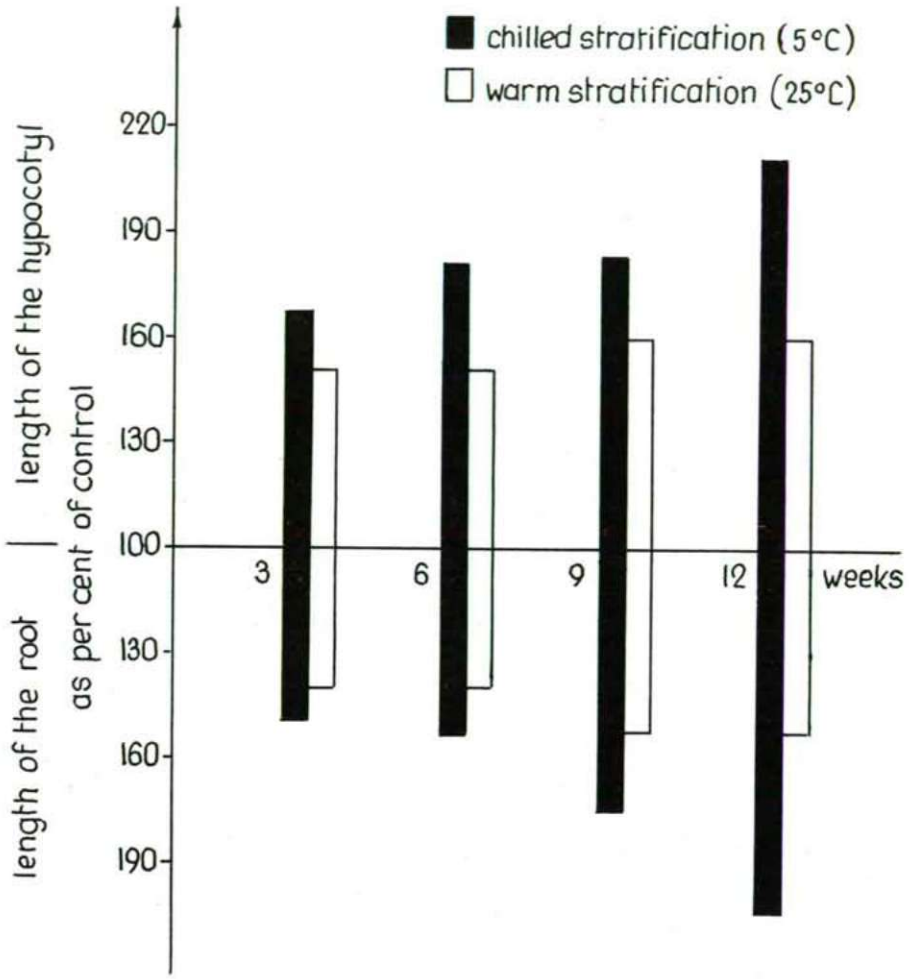


Fig. 4. Size of seedlings developed from embryos excised at various periods of stratification, observed on the seventh day after excision and expressed as percentages of the non-stratified control

Seedlings originating from chilled stratified embryos were at all investigated periods larger than seedlings developed from warm stratified embryos, indicating clearly that chilled stratification plays an important role in the increase of the capability of growth of the embryo. These statements are supported also by our results concerning the investigation of the degree of verdure (Fig. 5, A and B). As shown by these figures, in the leaves of the seedlings developed from chilled stratified embryos the formation of chlorophyll is more intensive than in the seedlings developed from warm stratified embryos.

Effect of the mechanical resistance of the surrounding tissues on the dormancy of the embryo

Low temperature may exert a favourable effect on the germination of seeds in two directions:

1. it may increase the capability of growth of the embryo which may represent at the end of the period of chilled stratification a greater stretching force against the surrounding tissues whose mechanical resistance remained unchanged, and thus the radicle will be capable of breaking through the surrounding tissues,

2. during the chilled stratification also the mechanical resistance of the surrounding tissues may decrease and this promotes the breakthrough of the radicle.

As indicated by our results presented thus far, the capability of growth of the embryo increases during the chilled stratification. However, the capability of growth

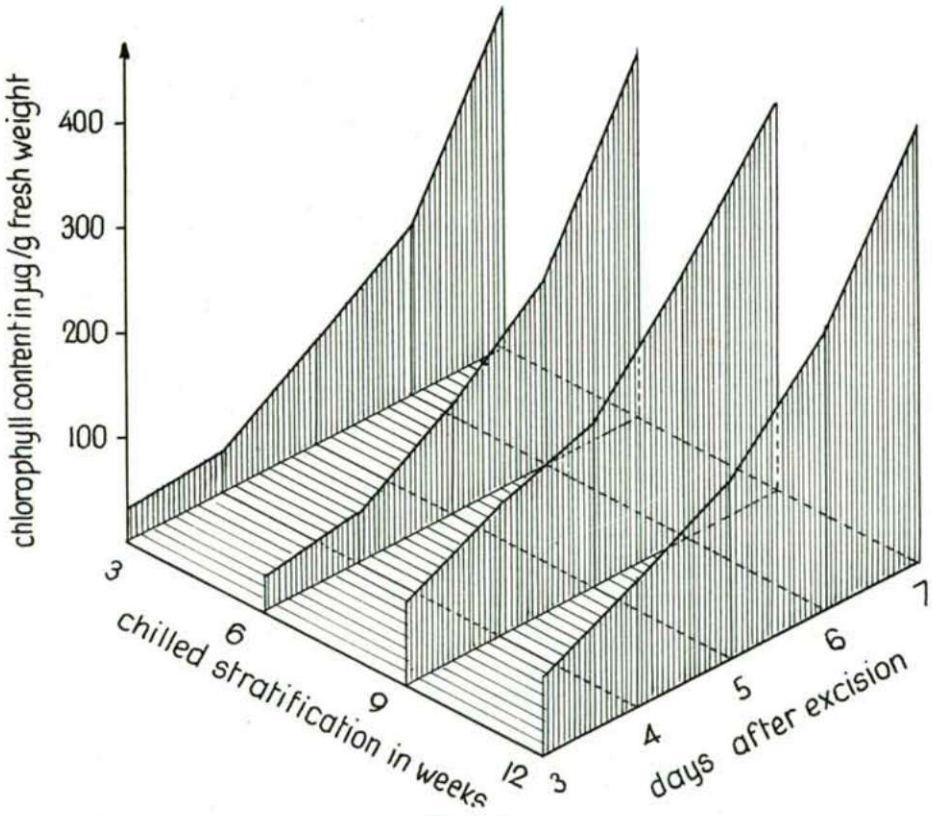


Fig. 5. A

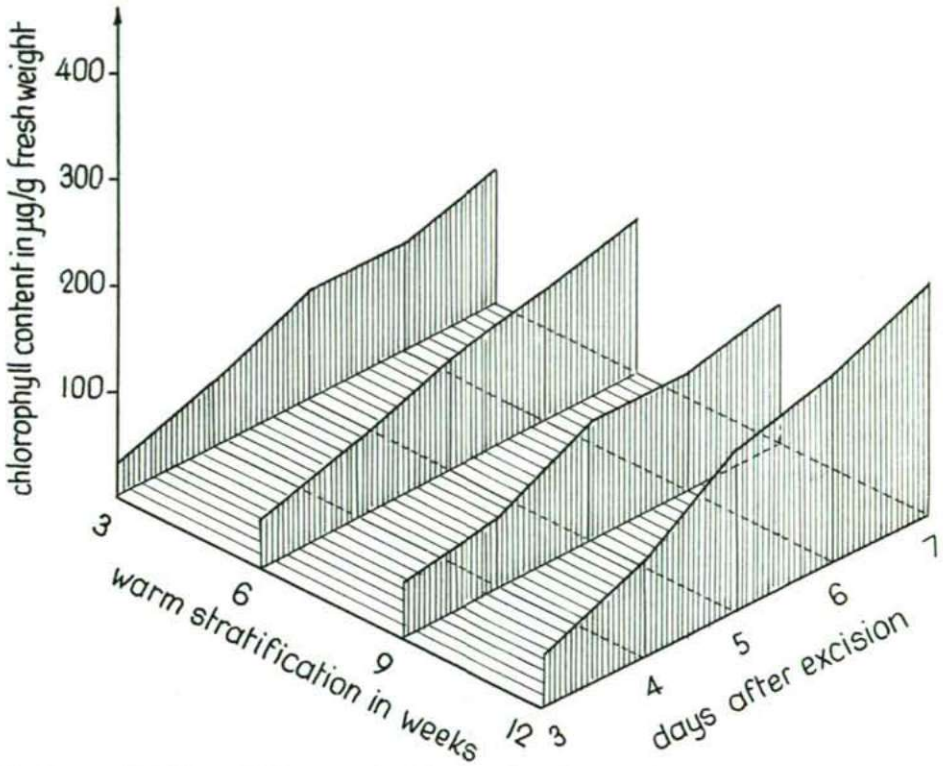


Fig. 5. (A and B) Chlorophyll content of the leaves of seedlings developed from embryos excised at various periods of stratification, determined for 7 days after excision

increases also during warm stratification in comparison to the capability of the non-stratified control, furthermore even on the effect of a treatment with exogenous GA_3, in certain cases to such an extent that the embryo gets crushed in the seed as an accordion (SZALAI and NAGY, 1968), and the radicle cannot break through the surrounding tissues.

In connection with the possible role of the mechanical resistance of the tissues surrounding the embryo in dormancy the effect of the breaking up of the ends of the seeds at the radicle or the apex, respectively, was investigated on the germination of seeds.

This operation was carried out after disinfecting the seeds by bromine water. This was done manually at diffuse light, with the use of a scalpel, a lance-shaped needle and a dissecting needle, then the seeds were placed in a Petri dish on sterile filter paper wetted with water containing 100 μg/ml streptomycin and incubated in a 25 °C thermostat. The result visible on the fourth day after this operation is shown in Fig. 6.

Seeds operated at their end near the radicle germinated in all cases, quite independently of being treated previously by chilling. The higher growth intensity observable in chilled stratified seeds is quite in accordance with our earlier results ob-

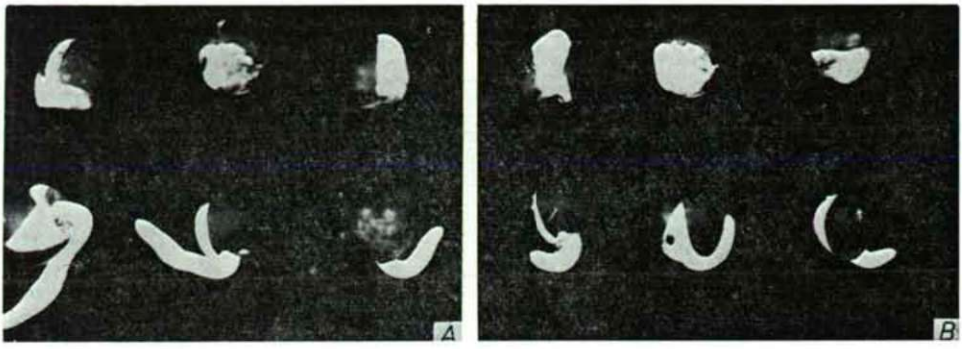


Fig. 6. Effect of operative treatment on the germination of seeds
A: seeds stratified at 5 °C for 2 months
B: seeds stratified at 25 °C for 2 months.

tained with excised embryos. In contrast to that, germination was not observed at all in seeds operated at their ends near the apex.

Attempts were made to clear up the role of the mechanical resistance of the tissues surrounding the embryo by experiments where the seeds were treated with exogenous cellulase and pectinase. Our aim was here to weaken the mechanical resistance of tissues surrounding the embryo and to observe the germination of seeds at 5 °C and at 25 °C.

The best results were obtained at the treatment with 1% cellulase. Experimental data are shown in Fig. 7, where the dark columns refer to seeds with intact seed-coat and the light columns to results obtained with seeds whose seed-coat was previously removed.

It can be seen in Fig. 7 that 100% germination could be observed in case of seeds whose seed-coats were removed and which were kept after their treatment with the cellulase preparation for one month at 5 °C and were subsequently treated with GA_3+ +IAA. The percentage of germination was in case of seed-coat-less seeds in all the cases higher than in tests with intact seeds. The results indicated as well that at low temperature the treatment with hormones is more efficient than at higher temperature. This may be in correlation with the conditions of the entrance of the hormones.

Thus, the primary role of chilled stratification may be likely not the ensuring of the growth of the embryo but rather the increase of the capability of germination of the embryo. Simultaneously with this process a weakening of the mechanical resistance of the tissues surrounding the embryo occurs on the effect of enzymes of key importance whose synthesis or activation starts at the impulse of chilled stratification. This presumption is confirmed also by the results obtained with other species requiring chilled stratification (OLNEY and POLLOCK, 1960; VILLIERS and WAREING, 1965; VANSTONE and LA CROIX, 1975), in experiments wherein the growth of embryos could be experienced during warm stratification but germination started only after chilled stratification. It can be imagined that similarly to the observations made in case of celery (JACOBSON et al., 1976) also in the lime seeds a quicker degradation of the cells located in the environment of the radicle occurs at low temperature.

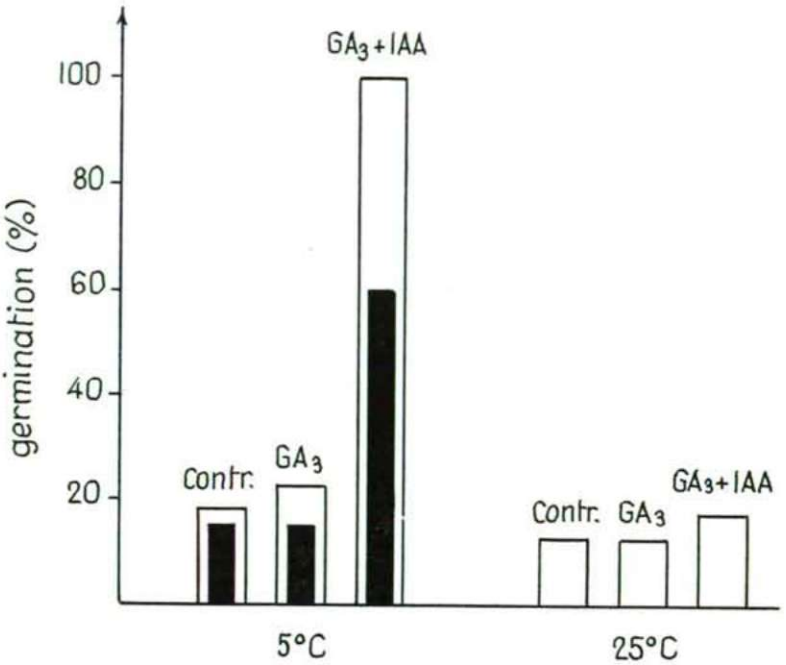


Fig. 7. Effect of exogenous cellulase treatment on the germination of seeds. Dark columns indicate the results obtained with scarified seeds whereas light columns show the results obtained with seeds whose seed-coats were removed previously.

References

AMEN, R. D. (1968): A model of seed dormancy. — Bot. Rev. *34*, 1—31.

BASKIN, J. M. and BASKIN, C. C. (1970): Replacement of chilling requirement in seeds of *Ruellia humilis* by gibberellic acid. — Planta *94*, 250—258.

FRANKLAND, B. (1961): Effect of gibberellic acid, kinetin and other substances on seed dormancy. — Nature, *192*, 678.

FRANKLAND, B. and WAREING, P. F. (1962): Changes in endogenous gibberellins in relation to chilling of dormant seeds. — Nature *194*, 313—314.

FRANKLAND, B. and WAREING, P. F. (1966): Hormonal regulation of seed dormancy in hazel and beech. — J. Exp. Bot. *17*, 596—61.

JACOBSEN, J. V., PRESSMAN, E. and PYLIOTIS, N. A. (1976): Gibberellin-induced separation of cells in isolated endosperm of celery seed. — Planta *129*, 113—122.

JUNTILLA, O. (1970): Effects of stratification, gibberellic acid and germination temperature on the germination of *Betula nana*. — Phys. Plant. *23*, 425—433.

NAGY, MÁRIA (1976): Dormancy in fruits of *Tilia platyphyllos* Scop. III. The possible role of auxin and cytokinin in the breaking of dormancy. — Acta Biol. Szeged. *22*, 47—55.

NAGY, MÁRIA (1980): Dormancy in fruits of *Tilia platyphyllos* SCOP. IV. Changes in the endogenous gibberellin content during the stratification of the seeds. — Acta Agron. *29*, 1—11.

NAGY, MÁRIA and SZALAI, I. (1973): Dormancy in fruits of *Tilia platyphyllos* SCOP. I. — Acta Biol. Szeged, *19*, 71—77.

OLNEY, H. O. and POLLOCK, B. M. (1960): Studies of rest period. II. Nitrogen and phosphorus changes in embryonic organs of after-ripening cherry seed. — Plant Physiol. *35*, 970—975.

SÁRKÁNY, S. and SZALAI, I. (1957): Növényszervezettani gyakorlatok (Phytomorphological exercises) (in Hungarian). — Tankönyvkiadó, Budapest, Hungary, pp. 524—577.
SZALAI, I. and NAGY, MÁRIA (1968): The causes of dormancy in *Fraxinus excelsior* L. fruits and the role of gibberellic acid in breaking dormancy. — Acta Bot. Acad. Sci. Hung. — *14*, 425—433.
SZALAI, I. and NAGY, MÁRIA (1974): Dormancy in fruits of *Tilia platyphyllos* SCOP. II. The inhibitor substance content of dormant fruits. — Acta Bot. Acad. Sci. Hung. — *20*, 389—394.
VANSTONE, D. E. and LA CROIX, L. J. (1975): Embryo immaturity and dormancy of black ash. — J. Am. Soc. Hort. Sci. *100*, 630—632.
VILLIERS, T. A. and WAREING, P. F. (1965): The possible role of low temperature in breaking the dormancy of seeds of *Fraxinus excelsior* L. — J. Exp. Bot. *16*, 519—531.
WHITE, P. R. (1943): A handbook of plant tissue culture. — Catell Press Lancaster.

Address of the authors:
DR. MÁRIA NAGY
ÁGNES KÉRI
Department of Plant Physiology
DR. SZERÉN PATAKY
Department of Botany,
A. J. University, H-6701 Szeged, Hungary

Acta Biologica Szeged. 27 (1—4), pp. 139—143 (1981)

EFFECT OF BUTACHLOR (2-CHLORO-2,6 DIETHYL-N-(BUTOXY-METHYL)-ACETANILIDE) ON THE ACTIVITY OF THE INDOLEACETIC ACID OXIDASE OF MAIZE SEEDLINGS

IRMA TARI, ERZSÉBET KÖVES and MARGIT SZABÓ

Department of Plant Physiology, Attila József University, Szeged

(Received September 12, 1980)

Abstract

The indoleacetic acid oxidase activity of roots of maize seedlings grown in a culture solution was greatly increased in the presence of 10 and 20 mg/l butachlor, a chloroacetanilide herbicide. The increased indoleacetic acid oxidase activity of roots combined with the simultaneous inhibition of the basipetal transport of auxin from the shoot may result in a high endogenous auxin level at the first internode of the shoot. This may explain the vigorous root induction observed in the presence of butachlor in the region of the adventitious roots.

Introduction

Our previous observations revealed that high concentrations of butachlor caused morphological changes in the roots of maize seedlings grown in a soil culture. The number of second-order branchings decreased and an increased formation of adventitious roots was observed at the first internode of the shoot (TARI et al., 1978). KEELY et al. (1972) reported a similar phenomenon during the development of the lateral roots of cotton treated with butachlor. Since the formation of lateral roots and root branchings are controlled by auxin, investigations concerning the auxin metabolism of maize treated with butachlor were carried out. In the present paper we deal with the decomposition of indoleacetic acid (IAA) in the roots of maize seedlings treated with butachlor.

Materials and Methods

Maize seedlings (*Zea mays* L.) var. Keszthelyi SC hybride served as test plants.

Butachlor was a commercial product of the Nitrokémia Factory. Seedlings were grown in a diluted Knop culture solution (pH 6,8) for 14 days with 16 hours of daylight, a daytime temperature of 24 °C and a nighttime temperature of 18 °C, a relative humidity of 60%, under 6500 lx. The herbicide treatment was carried out on the 14th day, applying a nutrient solution containing 10 and 20 mg/l of butachlor.

The IAA oxidase activity of the roots was measured in the 2nd, 6th, 12th, 18th and 26th hours after the treatment. The roots were excised and the fresh plant material was homogenised in 20 ml of a phosphate buffer (pH 4,5). After centrifugation at 3500 (g/20 min, 4 °C) the enzyme activity of the supernatant was measured at 28 °C. Reaction mixture contained 0,003 mmol IAA, 0,01 mmol

$MnSO_4$, 0,001 mmol dichlorophenol and 1,5 ml of enzyme extract in 10 ml of 0,15 mol KH_2PO_4 adjused to pH 4,5.

After thirty minutes incubation aliquots were mixed with Gordon-Weber reagent and absorbancies were read after 15 min. by spectrophotometer at 530 nm.

The protein content of the extract was determined by the method of LOWRY et. al. (1951).

Results and discussion

The uptake of the herbicide taken as a function of time has already been investigated by our laboratory (TARI et al., 1978) under identical experimental conditions applied in the present experiments.

The uptake of isotope-labelled butachlor by the roots proved to be insignificant within two hours after the treatment. The accumulation of herbicide increased later but in the shoot the ^3H-butachlor could be detected only in traces even after 24 hours.

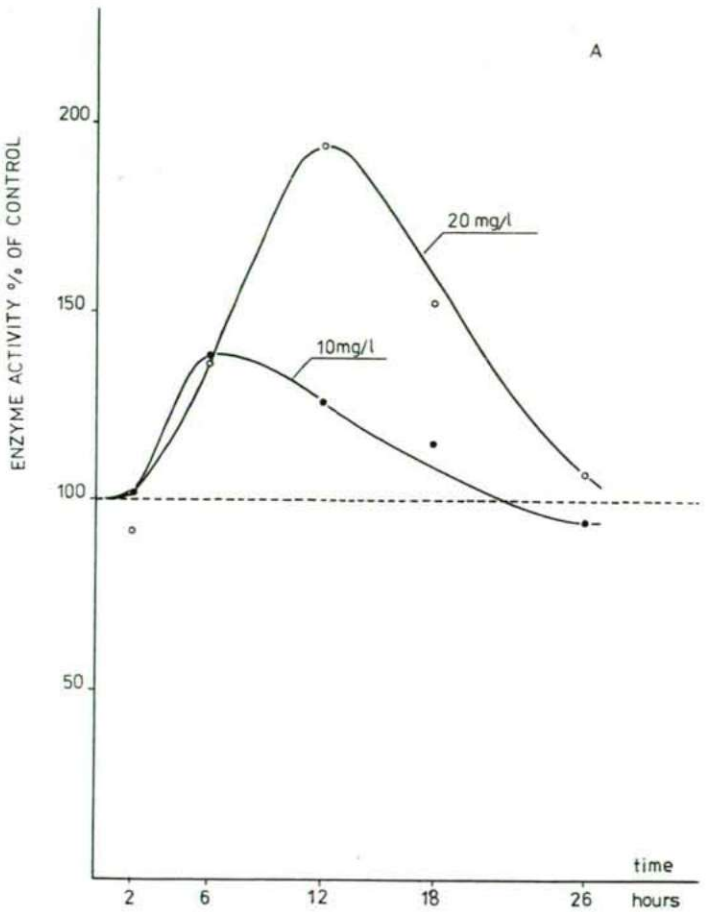


Fig. 1. a

Adding butachlor directly to the reaction mixture prepared with the untreated plant extract, enzyme activity is not affected by the herbicide over the concentration range 0,1—20 mg/l, whereas significant changes were observed in the IAA destructing activity of the enzyme preparation obtained from the plant treated with butachlor (Fig. 1).

According to Fig. 1/A. per gram fresh weight the enzyme activity changes in accordance with the changes in herbicide uptake as a function of time. In the first two hours after the treatment intensity of the decomposition of IAA does not change because the herbicide uptake via the roots can still barely be perceived in the 2-hour sample.

Later, however, significant increases can be observed in the enzyme activity in both applied butachlor concentrations. Per gram dry weight there is a decrease in

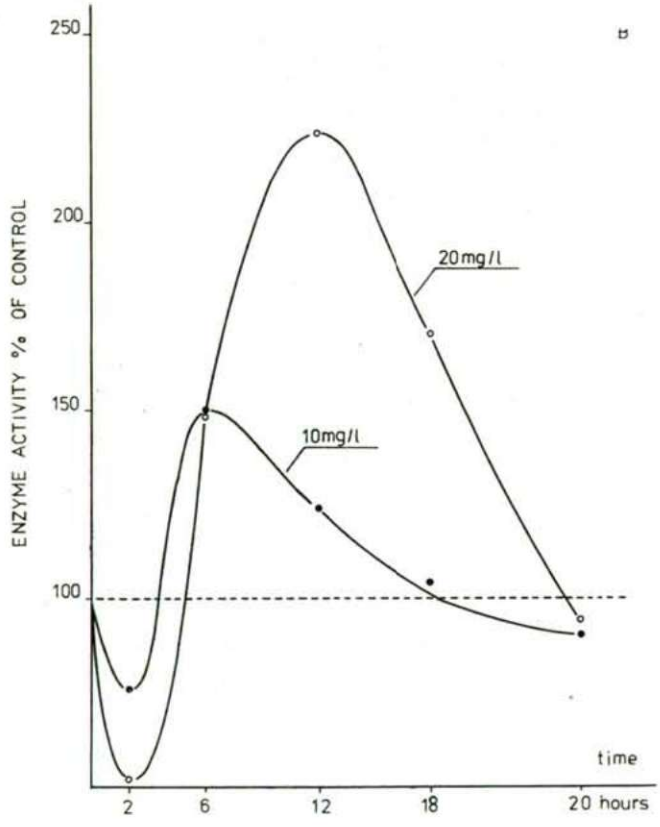


Fig. 1. b

Fig. 1. Effect of butachlor on the IAA oxidase activity of the roots of 14-day old maize seedlings on the fresh weight basis (A.) and on the dry weight basis (B.)
Enzyme activities are expressed as μg IAA oxidised per g fresh or dry weight per hour as a percent of control

IAA oxidase activity which corresponds with the significantly increased values of dry weight. It is believed that this phenomenon may be caused by the herbicide contacting with walls and membranes of root cells. So it alters their permeability which may lead to an increase in dry weight.

After 24 hours in both 10 and 20 mg/l butachlor solution a tendency of compensation can be observed. This decline in enzyme activity may be due to the lowering of the endogenous herbicide level. This is supported by the fact that the half-life of butachlor in maize proved to be 12 hours. The metabolism of chloroacetanilides in maize is very rapid and thus such an intense IAA degradation may be the consequence of an accumulation of metabolites of the herbicide. The mechanism of action of chloro-acetanilides such as butachlor is often explained by their inhibiting effect on protein synthesis (MANN et al., 1965; JAWORSKY et al., 1969; DEVLIN et al., 1970; AKOBUNDU et al., 1975; DUKE et al., 1975). However, in our experiments significant changes in protein content occurred only in the presence of 20 mg/l butachlor 12 hours after the treatment. This was preceded by an increase in the enzymatic decomposition of IAA, so the effect of the herbicide is probably not directly correlated with alterations in the protein synthesis.

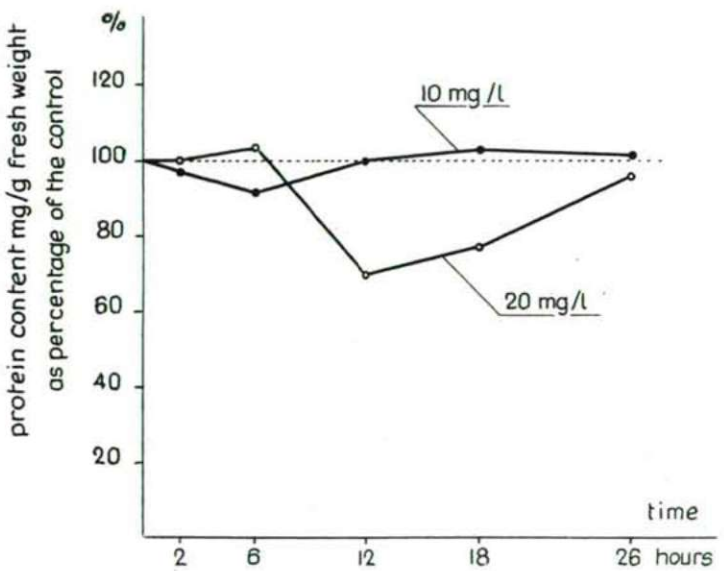


Fig. 2. Effect of butachlor on the protein content of the roots of two week-old maize seedlings
Concentrations applied: (•—•) 10 mg/l
(o—o) 20 mg/l butachlor
in a four-fold diluted Knop solution.
Incubation time: 26 hours.

According to some observations certain compounds promoting the oxidation of IAA at the same time decrease the basipetal auxin transport (STENLID, 1976). This could be proved in maize seedlings treated with butachlor where the basipetal IAA transport was inhibited by the herbicide (TARI et al., 1978) whereas the herbicide pro-

moted the IAA oxidase activity. The inhibiting effect of butachlor on the basipetal transport of IAA from the shoot when combined with the increase in IAA oxidase activity in the root can result in a low auxin level in the roots and a realtively high IAA level at the first internode of the shoot. Such an auxin distribution encourages the increased formation of the adventitious roots at the first internode-region.

References

AKOBUNDU, I. O., DUKE, W. B., SWEET, R. D. and MINOTTI, P. L. (1975): Basis for synergism of atrazine and alachlor combinations on japanese millet. — Weed Science *23*, 43—48.

DEVLIN, M. R. and CUNNINGHAM, R. P. (1970): The inhibition of gibberellic acid induction of α-amilase activity in barley endosperm by certain herbicides. — Weed Res.*10*, 316—320.

DUKE, W. B., SLIFE, F. W., HANSON, J. B. and BUTLER, H. S. (1975): An investigation on the mechanism of action of propachlor. — Weed Science *23*, 142—147.

JAWORSKY, E. G. (1969): Analysis of mode of action of herbicidal α-chloroacetamides. Journ. Agric. Food Chem. *17*, 165—171.

KATEKAR, G. F. and GEISSLER, A. E. (1977): Auxin transport inhibitors. 11. 2-(1-pyrenoyl)benzoic acid, a potent inhibitor of polar auxin-transport. — Aust. J. Plant Phsiol. *4*, 321—325.

KEELY, P. E., CARTER, C. H. and MILLER, J. H. (1972): Evaluation of the relative phytotoxicity of herbicides to cotton and nutsedge. — Weed Science *22*, 71—76.

LOWRY, O. H., ROSENBROUGH, N. J., FARR, A. L. and RANDALL, R. J. (1951): Protein measurement with the Folin phenol reagent. — J. Biol. Chem. *193*, 265—275.

Address of the authors:
DR. IRMA TARI
DR. ERZSÉBET KÖVES
DR. MARGIT SZABÓ
Department of Plant Physiology
A. J. University, H—6701 Szeged,
Hungary

Acta Biologica Szeged. *27* (1—4), pp. 145—154 (1981)

APPLICATION OF GROWTH INHIBITORS FOR DECREASING LAWN GRASS GROWTH

MAGDOLNA VARGA, MÁRIA SUM and JUDIT PARAGI

Department of Plant Physiology, Attila József University, Szeged

(Received September 2, 1980)

Abstract

For decreasing the shoot growth of lawn grasses solutions of maleic hydrazide (MH), ethrel and CCC of a concentration of 500, 1000, 2500 and 5000 ppm were tested as sprayings.

The shoot growth and mass increase of grasses which were sprayed once, twice and thrice gradually decreased with the increase of the concentration of the applied chemical agents and of the number of treatments. Growth was inhibited by MH to the greatest extent whereas the shortening of shoots induced by ethrel and CCC was in all cases weaker. In the majority of cases the growth decrease due to MH was about twice stronger than the effect of CCC as the least effective agent.

On applying the growth inhibitors in higher concentrations and repeatedly, the leaves suffered damages of smaller or greater extent. The phytotoxicity of the tested compounds proved to rise parallel with their growth inhibitor activity.

On applying MH and ethrel in higher concentrations and repeatedly, the contents of chlorophylls and carotenoids of the leaves were decreased significantly, and the degradation of chlorophylls was greater than that of yellow components. CCC in turn, increased in the majority of cases the amount of leaf pigments.

The concentrations of chemical agents and the ways of their application were established by means of which the growth decrease of lawn grasses can be attained without any damage of the leaves. For this purpose MH proved to be the most efficient of the three inhibitors tested. However, owing to its higher toxicity the hazards of its application are greater than those of ethrel or CCC whose effects are more moderate but their toxicity is lower.

Introduction

The maintenance of a nice and even green lawn in the parks and gardens is one of the most labour-intensive and cost-intensive operations of horticulture. Namely, the growth of the lawn must be continuously limited by regular mowing. However, the use of mowing machines requires expensive labour, motor fuels and much time. In addition to these, owing to frequent mowings the lawn consumes great amounts of nutrients. Therefore it appears to be expedient to find a simpler and more economical procedure for the decrease of grass growth.

In the knowledge of substances controlling plant growth the idea emerges that this problem might be solved by the application of adequate growth inhibitors in a chemical way. The chemical method is more up-to-date, quicker and much cheaper than the traditional methods, and thus it is of an immense practical importance.

Experiments in this direction have been carried out very sparsely throughout the world, and up to the present no experiments of this type were performed at all in Hungary (VARGA, 1976; SURÁNYI, 1978; FÜLEP, 1979). For the decrease of the growth of lawn grasses theoretically any synthetic growth inhibitor would be suitable e.g. the antiauxin-type TIBA and maleic hydrazide (MH); the antigibberellin-type growth retardants such as CCC, Phosfon-D, Amo-1618; furthermore the Alar (B_9), the ethrel and the morphactins. According to WEAVER (1972) the few inhibitors tested thus far did not give satisfactory results in case of lawn grasses. MADISON et al. (1969) applied morphactin as a growth inhibitor in case of blue grass, Bermuda grass and creeping bent grass but besides the inhibition of shoot elongation also an undesirable yellowing and phytotoxic effects occurred. It has been reported that MH inhibited the growth of pasture grasses with relatively good results (RUELKE, 1961) and thus this compound appears to be promising also for the limitation of lawn grass growth. The effect of other available inhibitors has been, in turn, not investigated thus far from this aspect.

Our experiments concerning the growth retardation of lawn grasses were started with MH, CCC and ethrel. MH is a general inhibitor of meristematic activity and is used since 1950 for the inhibition of the growth of trees, shrubs, stored potatoes and onions. CCC/ (2-chloroethyl)-trimethyl-ammonium chloride, chlorocholine chloride, Cycocel/ is applied since 1960 extensively for various practical purposes. CCC is considered generally as an antigibberellin i.e. a compound blocking in plant tissues the biosynthesis of gibberellins. It is probable however, that besides influencing the gibberellin level also other processes of metabolism are affected by CCC and its growth-inhibiting activity is correlated with the metabolism of other phytohormones as well (LETHAM et al., 1978). The ethylene generator ethrel /(2-chloroethyl)-phosphonic acid, CEPA/ is used in the practice since 1970. Quite a number of growth-physiological processes can be influenced by ethrel and, respectively, by ethylene liberated from it in the plant tissues; according to our investigations (VARGA and NIKL, 1981) it exerts a dwarfing effect when applied in higher concentrations and thus it is suitable also for the limitation of vegetative growth.

The aim of the present work was to test the suitability of the mentioned three, relatively cheap compounds for the decrease of the shoot growth of lawn grasses and to analyze the positive and negative reactions which deviated from those of the control plants. We set us the task to establish the concentrations and ways of treatment by which a growth reduction of lawn grasses to an extent desirable from practical aspects can be attained without the damage of the leaves.

Materials and Methods

Experiments were carried out with a seed sample denoted as "Grass mixture" which was suitable for grassing parks and domestic gardens. The seed mixture originated from the 1980 collection of the Vetőmagtermeltető és Értékesítő Vállalat (Enterprise for Producing and Marketing Seedgrains), Budapest. Of the components of this "Grass mixture", *Lolium perenne, Poa pratensis, Festuca rubra* and *Agrostis alba (stolonifera)* were present in the mixture in the greatest amounts.

Maleic hydrazide (MH) was prepared in the Department of Plant Physiology of the Attila József University, Szeged, in a crystalline form, its purity degree was 97.3%. CCC was a powdered product of Sigma Chemical Co. (U.S.A.), and ethrel was a liquid product of the Chinoin Factory Ltd. (Budapest) containing 40% of active substance and marketed under the name Rol-Fruct.

The seeds were sown into 10×10 cm plastics dishes filled with garden mould soil. The seedgrain requirement was 5 g/dm², the depth of sowing 0.5 cm. The plants were grown in a greenhouse

at a daily illumination rhytm of 16/8 hours at a temperature of 24±1 °C. A stable soil water content was maintained by irrigation with tap water controlled by weighing.

At an age of ten days the grasses were cut evenly to 4 cm and their spraying was started with an aqueous solution of the growth inhibitors of a concentration of 500, 1000, 2500 and 5000 ppm, respectively. The polyglycol derivative Citowett (BASF AG, BRD) served as wetting agent. A part of the grasses was sprayed once whereas another part of them obtained leaf spraying twice and thrice in weekly periods. The control plants were treated with tapwater containing wetting agent. Spraying was carried out in every dish with a manual sprayer device, on using equal amounts of solutions.

Prior to the first treatment and subsequently in ten-day periods samples were withdrawn from the plants and the lenght, the fresh and dry mass, and the leaf pigment content of the shoots, the mars increase of the roots were measured, furthermore the eventual leaf damages and their extent wese recorded.

The extraction of leaf pigments was carried out according to DÁNIEL (1963) in the presence of $MgCO_3$ with a 1:1 mixture of acetone: ethylether. Then acetone was washed off the extract with water and the pigments were shaken over into ethylether. The absorption of the ethereal pigment extracts was measured by a UV/VIS spectrophotometer at the wavelengths 430 nm (carotenoids), 625 nm (protochlorophyll), 645 nm (chlorophyll-a) and 665 nm (chlorophyll-b). At the calculation of the concentration of chlorophylls (μg/g fresh mass) the formula given by WITHROW et al. (1953) was used. The total carotenoid content is expressed by the values A_{430}.

Each investigation was carried out in triplicates.

Results and discussion

On investigating the growth inhibition of the lawn grass mixture it must be taken into account that the plant stand is heterogeneous i.e. it consists of various grasses. Though the individual components are affected by the growth inhibitors separately to various extents (SUM, 1978), in our experiments the total effect of these compounds on the grass mixture i.e. the average reaction of the various species is actually observed. Thus, our task was to find ways of treatment and concentrations of chemical agents which ensure for all the components the best result obtainable from the aspect of both growth inhibition and toxicity.

Effect of growth inhibitors on shoot growth

For the decrease of shoot growth of the lawn grass mixture four various concentrations of MH, ethrel and CCC were tested in the interval from 500 to 5000 ppm, and sprayings carried out once or twice or thrice. The shoot lengths observed at the end of the 30-day experimental period are shown in Figs. 1, 2 and 3 whereas the percentages of growth decrease are summarized in Table 1. According to the experimental data the shoot growth was inhibited by all the three inhibitors tested, proportionally to the increase of the concentration of chemicals and of the number of sprayings, to a gradually increasing extent. However, on comparing the results obtained with the investigated three compounds it appears that their growth-inhibiting activity and the reaction of lawn grasses induced by them is rather different.

The shoot growth of grasses was decreased by MH to the greatest extent (Table 1, and Fig. 4) whereas the inhibition of growth induced by ethrel and CCC was in all cases weaker than that which could be obtained with MH of identical concentration. In the majority of samples MH caused about twice as great growth decrease, expressed in percentages, than CCC which proved to be the least efficient as an inhibitor of shoot growth of grasses (Table 1). Consequently, lawn grasses are more sensitively reacting to MH than to ethrel and CCC.

Table 1. Decreasing effect of growth inhibitors on the shoot growth of lawn grasses
Degree of growth decrease observed on the thirtieth day, expressed as percentages of the control plants

Number of sprayings	Growth inhibitor	Concentration, ppm			
		500	1000	2500	5000
1	MH	23%	45%	50%	62%
	Ethrel	18	22	29	45
	CCC	15	20	24	32
2	MH	32	49	55	63
	Ethrel	21	26	36	52
	CCC	16	25	30	40
3	MH	42	52	56	67
	Ethrel	27	30	41	59
	CCC	26	29	43	51

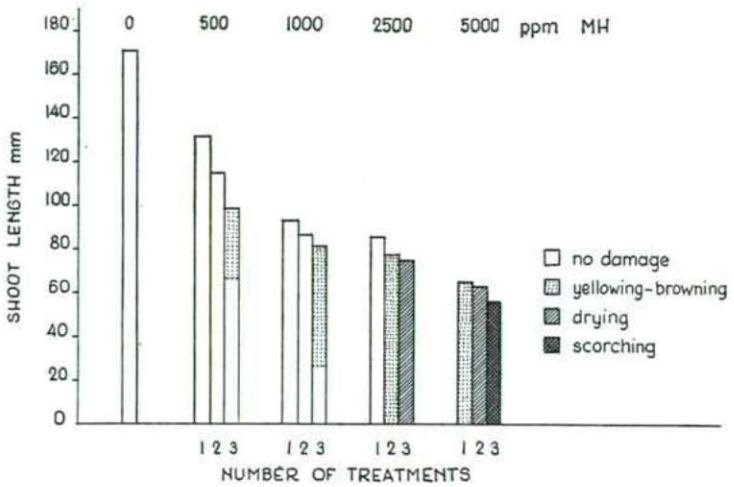


Fig. 1. Shoot growth and leaf damages of lawn grasses on the effect of sprayings with MH, on the thirtieth day after the first treatment

On evaluating the leaf damages due to sprayings it appears that the phytotoxicity of the compounds increases parallel with their growth-inhibiting activity and, respectively, with the sensitivity of lawn grasses to the compounds. MH as the growth inhibitor which proved to be the most efficient caused, when applied in a concentration of 500 to 1000 ppm consecutively thrice, yellowing and browning of a part of the leaves. With the increase of concentration the toxic symptoms became stronger, and the plants treated thrice with a 5000 ppm MH solution were destroyed on the 30th day due to drying (withering) and scorching (Fig. 1). Ethrel caused only in a concentration of 2500—5000 ppm leaf damages whose extent was smaller or greater accord-

ing to number of the applied sprayings (Fig. 2) whereas CCC caused observable leaf damages only in the case when it was applied in the highest concentration and repeatedly (Fig. 3).

It must be noted that in case of grass samples which did not suffer any damages the decrease of apical growth resulted in a more compact form, higher resistance to lodging and stronger stooling than those observed in the control plants. This is particularly valid in case of plants sprayed with CCC.

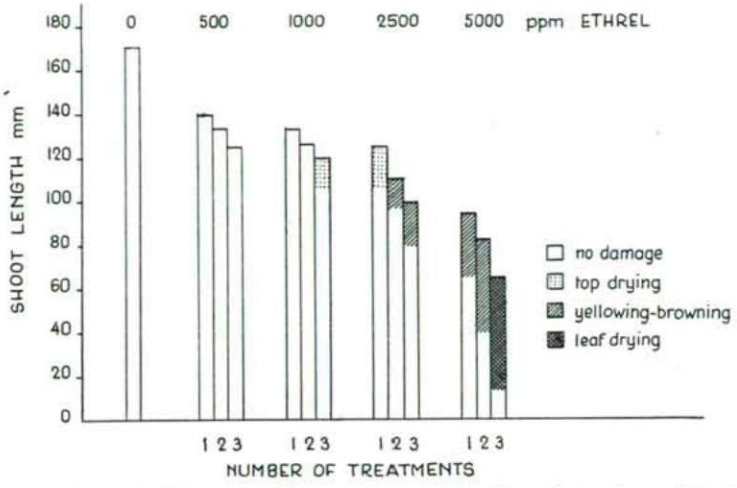


Fig. 2. Shoot growth and leaf damages of lawn grasses on the effect of sprayings with ethrel, on the thirtieth day after the first treeatment.

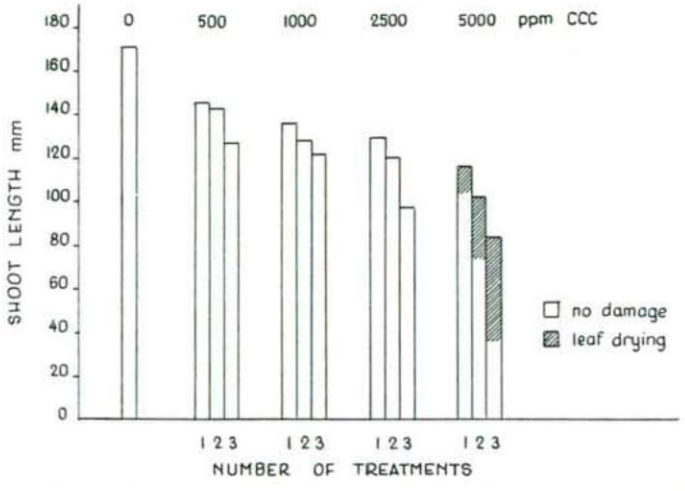


Fig. 3. Shoot growth and leaf damages of lawn grasses on the effect of sprayings with CCC, on the thirtieth day after the first treatment.

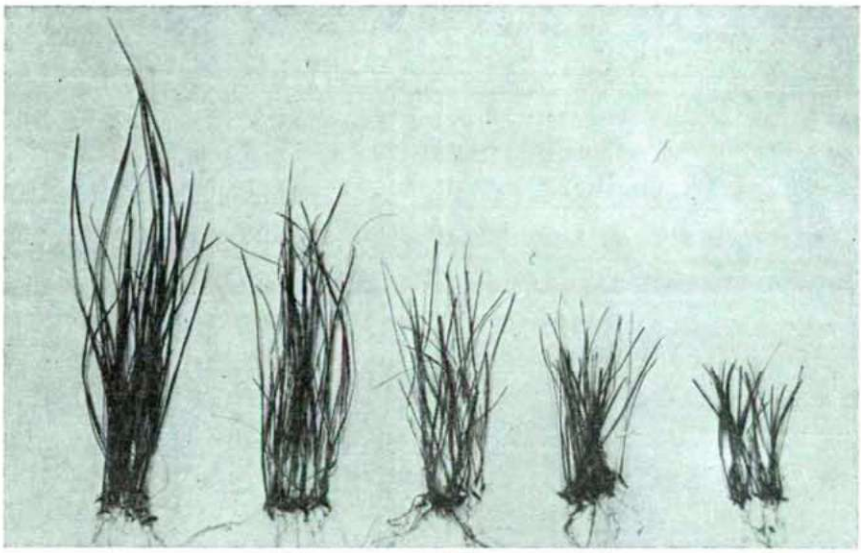


Fig. 4. Shoots of lawn grasses sprayed once with various concentrations of MH, on the thirtieth day after the treatment.

Effect of growth inhibitors on the increase of the fresh and dry mass of shoots

The growth-inhibiting effect of spraying with growth inhibitors carried out once, twice and thrice can be established also by observing the fresh mass of shoots (Table 2). In case of MH and ethrel the fresh mass decreased more and more with the increase of the concentrations and with the increase of the number of treatments. Consequently, mass accumulation is in concordance with the apical growth. In contrast to that, the increase of the fresh mass of shoots of lawn grasses sprayed with CCC did not

Table 2. Effect of growth inhibitors on the fresh mass increase of the shoots of lawn grasses Fresh mass (g) on an area of 10×10 cm, on the thirtieth day

Number of sprayings	Growth inhibitor	Concentration, ppm				
		0 (control)	500	1000	2500	5000
1	MH	10.13	6.98	5.97	5.06	2.73
	Ethrel		9.86	9.04	6.65	6.12
	CCC		10.84	10.43	9.62	8.10
2	MH	10.13	5.47	5.06	3.74	2.43
	Ethrel		9.62	8.12	7.30	5.39
	CCC		10.53	9.52	8.91	7.49
3	MH	10.13	4.96	4.92	2.93	2.23
	Ethrel		7.95	7.26	6.67	4.63
	CCC		10.10	9.21	8.30	6.88

show any parallelism with growth intensity. Namely, lower concentrations of CCC despite their certain growth-inhibiting effect rather increased the fresh mass instead of decreasing it. Though the fresh mass of shoots treated with higher CCC concentrations indicated some decrease when compared to that of the control plants, the degree of this decrease was not proportional to the inhibition of apical growth. This points to the more compact form, thicker foliage and higher water content of grasses treated with CCC.

The dry matter content of shoots does not show any parallelism with the degree of decrease of fresh mass caused by any of the growth inhibitors tested. Moreover, the percentage of dry mass in grasses sprayed repeatedly by higher MH concentrations exhibited even some rise when compared with that of the control (Table 3). This can be attributed certainly to the water loss due to the drying of leaves caused by the compunds.

Table 3. Effect of growht inhibitors on the dry mass increase of the shoots of lawn grasses expressed as percentages of dry mass

Number of sprayings	Growth inhibitor	Concentration, ppm				
		0 (control)	500	1000	2500	5000
1	MH	16.5	16.2	16.1	16.0	16.8
	Ethrel		15.8	14.3	14.5	14.8
	CCC		16.0	15.1	15.3	15.5
2	MH	16.5	15.5	16.1	16.6	16.8
	Ethrel		14.1	13.4	14.4	15.0
	CCC		15.0	13.5	15.0	16.2
3	MH	16.5	14.6	16.0	16.8	17.0
	Ethrel		13.4	14.2	15.3	15.8
	CCC		14.0	14.6	15.7	16.0

Effect of growth inhibitors on the content of leaf pigments

The growth decrease of lawn grasses induced by chemical agents can be successful only if the green colour and exterior look of the lawn is not affected adversely by the treatment with chemicals. Therefore it was necessary to measure in every sample the effect of sprayings on the content of leaf pigments.

The content of chlorophyll a + b (Fig. 5) was not affected appreciably by a single treatment with the 500, 1000 and 2500 ppm solutions of MH, nor by single or thrice repeated treatments with a 500 ppm solution of ethrel or a single or repeated treatment with a 1000 ppm solution of ethrel. In all the aforementioned cases the deviations from the control values were within the 10% error limit. In all other samples the amount of chlorophylls was significantly decreased by both compounds with the rise of the concentration and of the number of spryaings. The degradation of chlorophylls is of a particularly high degree (42 and 38%, 55 and 50%, 58 and 57%, respectively) in the leaves of grasses treated thrice with 2500 ppm solutions of MH and ethrel,

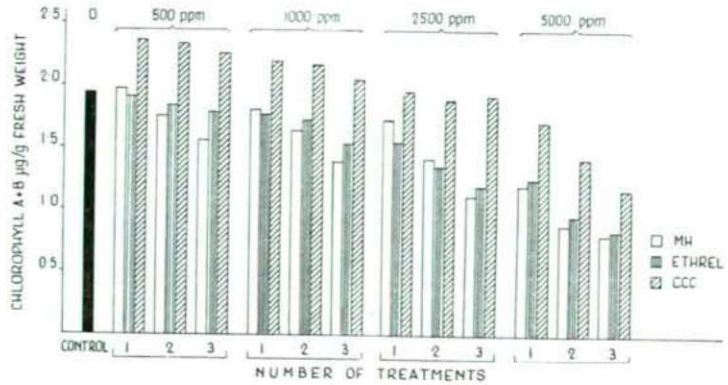


Fig. 5. Effect of MH, ethrel and CCC on the total chlorophyll content of the leaves of lawn grasses (on the thirtieht day).

and treated twice and thrice with 5000 pm solutions of MH and ethrel. The effect of MH and threl on the chlorophyll content proved to be about the same whereas CCC disclosed an effect differing from that of both other compounds. Namely, lower concentrations of CCC definitely raised the total chlorophyll concentration of the shoots which manifested itself by a darker colour observable also visibly. The amount of chlorophylls was decreased significantly by this compound only in lawn grasses repeatedly sprayed with its highest concentrations. The higher chlorophyll level obtained with non-toxic concentrations of CCC and its effect increasing the net photosynthetic production was observed by a number of authors in various plants (LETHAM et al., 1978).

The total carotenoid content of the leaves showed a similar behaviour (Fig. 6) with the difference that the concentration dependent alteration of the amount

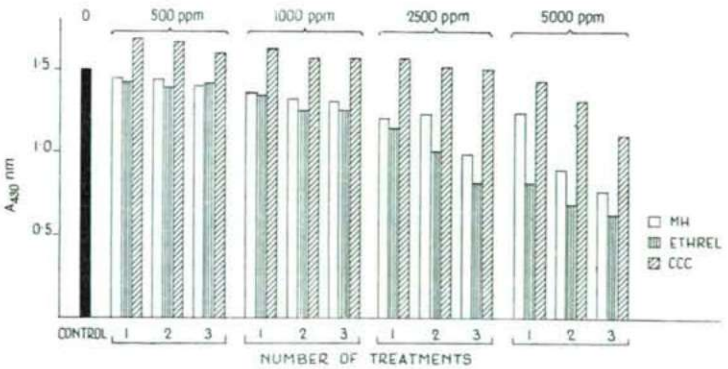


Fig. 6. Effect of MH, ethrel and CCC on the total carotenoid content of the leaves of lawn grasses (on the thirtieht day).

of yellow pigments was of a degree lower than that of the green components. Consequently, mainly on the effect of concentrated solutions of MH and ethrel, chlorophylls were degraded to a degree higher than that of carotenoids.

Successful ways of treatment for lawn grass mixture

On comparing the shoot growth inhibiting effect of sprayings with solutions of MH, ethrel and CCC of various concentrations and applied once or repeatedly with the damages of leaves observable visibly in their colour or in their other properties, it can be established which compounds and ways of treatment may be applied in practice for the successful and hazardless growth decrease of lawn grasses. Namely, in order to avoid a frequent lawn mowing the apical growth must be deceased by 45 to 50%.

According to our results a growth inhibition of this order of magnitude or higher can be obtained most of all with MH, of the compounds tested (Table 1). However, on taking into account the phytotoxic effect of treatments with higher concentrations of MH, practically only a single or repeated spraying with a 1000 ppm solution or a single spraying with a 2500 ppm solution can be applied. These types of treatment proved to result in a decrease of shoot elongation by 45, 49 and 50% without any visible damage of the leaves (Fig. 1) i.e. their effect is satisfactory from the aspect of the aim set by us.

Though a once to thrice applied spraying with a 500 ppm ethrel solution and a once or twice applied spraying with a 1000 ppm ethrel solution did not damage the leaves and leaf pigments (Figs. 2, 5 and 6), the observed decrease of shoot growth was unsatisfactory (only 18 to 27%).

CCC when applied repeatedly in both lower concentrations did not damage at all the grasses. Instead, it increased the pigment content, mass and resistance to lodging of the leaves (Figs. 3, 5 and 6). Still, CCC is not suitable for attaining the desired aim because the growth inhibition induced in this way is rather low (15 to 26%). A more significant growth decrease (up to 30—43%) without any phytotoxic symptoms can be obtained only by spraying with a 2500 ppm solution carried out twice or thrice. Thus, only these types of treatment can be taken into account in order to attain a rather moderate but hazardless result.

On summarizing our results it can be stated that of the three inhibitors tested MH proved to be the most efficient for the growth decrease of the lawn grass of parks and gardens. Namely, on applying MH twice as strong growth inhibition can be obtained without any damage of the leaves than that attainable with ethrel or CCC. Just therefore, MH can be applied with better results but at higher hazards (due its higher toxicity) than ethrel or CCC which have moderate effects but lower hazards.

Also experiments with other growth inhibitors are in progress under greenhouse and small-plot conditions.

References

DÁNIEL, F. Á. (1963): Increased photosensitivity of leaf pigments and its relation to the respiratory system in albino mutants of corn. — Physiol. Plant. *13*, 227—236.

FÜLEP, M. (1979): Növekedésszabályozó anyagok gyakorlati alkalmazásának helyzete Magyarországon (1974—1979). (State of the practical application of plant growth substances in Hungary (1974—1979).) — (In Hungarian) — Thesis. Department of Plant Physiology, Attila József University, Szeged, Hungary.

MADISON, J. H., JOHNSON, J. M., DAVIS, W. B. and SACHS, R. M. (1969): Testing fluorene compounds for chemical mowing of turf grass. — Calif. Agr. *23*, 8—10.

LETHAM, D. S., GOODWIN, P. B., HIGGINS, T. J. V. (1978): Phytohormones and related compounds: A comprehensive treatise. I—II. — Elsevier /North Holland Biochemical Press, Amsterdam—Oxford—New York.

RUELKE, O. C. (1961): Winter injury of Pangola grass reduced by use of maleic hydrazide. — Agron. Journ. *53*, 405—406.

SUM M. (1978): Maleinhidrazid felhasználása gyepfüvek növekedésének korlátozására. (Use of maleic hydrazide for the limitation of the growth of lawn grasses.) – (In Hungarian) — Thesis. Department of Plant Physiology, Attila József Unievrsity, Szeged, Hungary.

SURÁNYI D. (1978): Növekedésszabályozók a kertészetben. (Growth-controlling agents in horticulture.) — (In Hungarian) — Mezőgazdasági Kiadó (Publishing House for Agriculture), Budapest, Hungary.

VARGA, M. (1976): Növekedésszabályozó anyagok gyakorlati alkalmazása a növénytermesztésben. (Practical application of growth-controlling agents in plant growing.) — (In Hungarian) — University Lecture Notes, Department of Plant Physiology, Attila József University, Szeged, Hungary.

VARGA M. és NIKL K. (1981): A magyar gyártmányú ethrel (Rol-Fruct) növekedésélettani karakterizálása. (Growth-physiological characterization of ethrel (Rol-Fruct) manufactured in Hungary.) — (In Hungarian) — Acta Agronom. Acad. Sci. Hung. *30* (under publication).

WEAVER, R. J. (1972): Plant growth substances in agriculture. — W. H. Freeman and Co., San Francisco, U.S.A.

WITHROW, R. B., KLEIN, W. H., PRICE L. and ELSTAD, V. (1953): Influence of visible and near infrared radiant energy on organ development and pigment synthesis in bean and corn. — Plant Physiol. *28*, 1—14.

Address of the authors:
DR. MAGDOLNA VARGA
MÁRIA SUM
JUDIT PARAGI
Department of Plant Physiology
A. J. University, H-6701 Szeged,
Hungary

Acta Biologica Szeged. *27* (1—4), pp. 155—158 (1981)

ADAPTATION OF MAYFLY LARVAE TO DIFFERENT SALINITIES

MÁRIA CSOKNYA

Department of Zoology, Attila József University, Szeged
(Received September 20, 1980)

Abstract

Chloride cells on the lamelliform gills of the larvae of *Cloeon dipterum* are of unequal dispersion. Their number depends on the external salinity. On the basis of their salt absorption they might take part in osmoregulation.

Introduction

Mayfly larvae have tracheal gills wich are lamelliform — or filiform ones, or these two forms can occure together (ÚJHELYI, 1959). Tracheal gills are known as respiratory organs, but a lot of data refer to the fact that they aren't the only places of respiration (SHARP, 1901; WESENBERG-Lund, 1943).

Gills especially lamelliform ones take part in other functions as well (EASTHAM, 1936; WICHARD, 1975) e.g. in osmoregulation that keeps the organism's salt and water balance independently of external salinity. Similar regulating structures are known both in Vertebrates (MUNSHI, 1964; SCHMIDT-NIELSEN and cow., 1964) and in Invertebrates (KAPOOR, 1978; WICHARD and cow., 1973).

We wanted to answer with our experiments wether larvae of *Cloeon dipterum* have this regulating system and what its efficiency is like? These are questions of interest because larvae are to be found in very different salinities (apart from extreme concentrations).

Materials and Methods

Our experiments were carried out on larvae of *Cloeon dipterum* (L.) (Ephemeroptera); these larvae were in last instar and approximately of the same size. We studied these larvae in water containing different quantity of sodium chloride. Larvae maintained in natural fresh water were taken as control. Diluted water was made by diluting natural fresh water with distilled water in the proportion of 1:1, 1:10, or 1:100; concentrated fresh water was obtained by adding various amounts of sodium chloride (16, 32 and 160 mM).

10 larvae were kept in the different solutions (10 larvae for each for 24 hours). The gills were removed; having fixed and stained by histochemical choride method (WICHARD and cows., 1973), they were processed for light microscope.

Results and discussion

2 pars of lamelliform gills are on each side of 1—7 abdominal segments. The members of the pairs are different only in size. Their tracheas form a rich network and join into the main visceral tracheal branch of the body.

Histological structure of the gills is similar to that of other mayfly larvae lamelliform gills, that is among their respiratory epithelial cells on their upper and lower surfaces there are chloride cells according to histochemical stain (WICHARD, 1975; WICHARD and cow., 1971, 1973).

Their distribution on the surfaces of the lamellae is unequal, most of them are on the middle and proximal part of the gills. Their number increases to 1—4 gill pair then suddenly decreases. The changing number of cells could be observed in the case of each applied concentration (Figs. 1, and 2). It this change is considered at increasing concentration of sodium chloride (Fig. 3) we can claim that the number of chloride cells per gill in diluted water is increasing but decreasing at gradually increasing concentration of sodium chloride.

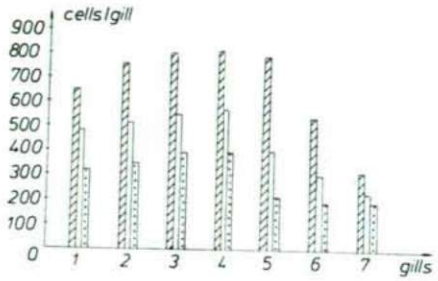


Fig. 1. Distribution of the chloride cells on the large gills of the larvae (clear column=in normal-striated column=in diluted-, dotted column=in concentrated water).

Table 1. Standard deviation of chloride cells per large gills

Number of gill	Diluted water	Normal water	Concentrated water
1.	n=10 652±1.054	n=10 482±3.80	n=10 320±2.44
2.	758±2.90	516±3.80 (n=9)	350±1.63
3.	805±4.29	558±4.85	390±3.74
4.	813±2.66	570±4.44	400±4.42
5.	795±4.83	402±3.62	219±2.26
6.	545±4.14 (n=8)	311±3.12	199±4.32
7.	323±4.41 (n=9)	231±1.88	200±2.35

The received data (Figs. 1, and 2). considering their standard deviation (Tables 1, and 2) indicate that sufficiently homogenous populations were used; and indicate an adaptive behaviour of the chloride cells too that is the larvae are able to tolerate a comparatively wide range of salinities. The increasing number of the cells may lead to the conclusion that these cells absorb salt from external presumably very hypo-osmotic environment and transfer to haemolymph. (We stress that even the external water at the control experiments can't be considered iso-osmotic in comparison with the haemolymph).

At the gradually increasing concentrations the decrease in the number of the cells can be correlated with the superfluous salt intake with food from external hyper-

Table 2. Standard deviation of the chloride cells per little gills

Number of gill	Diluted water	Normal water	Concentrated water
1.	n=10 135±3.80 (n=9)	n=10 80±2.74	n=10 25±2.21
2.	173±3.91	125±3.57	50±3.85
3.	183±3.68	116±4.30	50±3.07
4.	210±4.15 (n=8)	161±3.62	98±2.00
5.	176±2.05 (n=)	127±3.49	71±1.94
6.	195±0.816	64±2.36	30±1.63

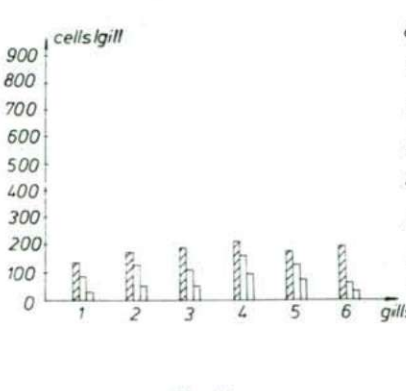


Fig. 2

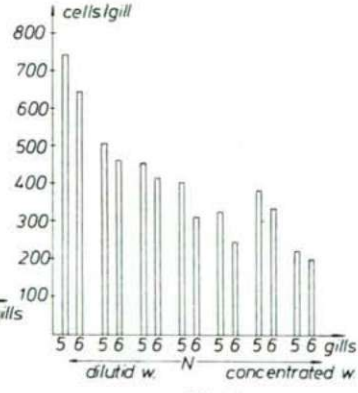


Fig. 3

Fig. 2. Distribution of the chloride cells on the small gills of the larvae (clear column=in normal-, striated column=in diluted-, dotted column=in concentrated water).

Fig. 3. Changing of the number of the chloride cells on 5. and 6. gills depending on the different salinities.

tonic environment. This time the salt-excretory activity is increasing in addition other cells and organs could also take part in salt secretion e.g. salt glands of marine birds or the chloride cells of marine fish (SCHMIDT-NIELSEN and cow., 1964).

Our light microscopic experiments can't prove these cells' ability of excreting salt.

Certain data doubt the excretory activity of these cells on the basis of experiments on other species with radioactive chloride.

Our experiments and results introduce the presence of the chloride cells and their changing number and indicate that they are members of a regulating mechanism. Further experiments are needed to clear what kind of changes happen in these cells.

References

EASTHAM, L. E. S. (1936): The sensillae and related structures on the gills of nymphs of the genus *Caenis* (Ephemeroptera). — Trans. R. Ent. Soc. Lond. *85*, 401—411.

KAPOOR, N. N. (1978): Effect of salinity on the osmoregulatory cells in the tracheal gills of the stonefly nymph *Paragnetina media* (Plecoptera: Perlidae). — Can. J. Zool. *56*, 2608—2613.

MUNSHI, D. J. S. (1964): Chloride cells in the gills of water teleosts. — Quart. J. micr. Sci. *105*, 79—89.

SCHMIDT-NIELSEN, K. and Y. T. (1964): The effect of salt intake on the size and function of the salt gland of ducks. — Auk. *81*, 160—172.

SHARP, D. M. A. (1909): The Cambridge Natural History. Insects II. Macmillan and Co., Limited st. Martin's street, London.

ÚJHELYI, S. (1959): Ephemeroptera. Fauna Hung. V.

WESENBERG-LUND, C. (1943): Biologie der Süsswasser-Insekten. — Nordisk Forlag, Kopenhagen und Verlag J. Springer Berlin, Wien.

WICHARD, W. (1975): Structure and function of the respiratory epithelium in the tracheal gills of mayfly larvae. — Proc. 2nd Int. Conf. on Ephemeroptera, Krakow.

WICHARD, W. and KOMNICK, H. (1971): Electron microscopical and histochemical evidence of chloride cells in tracheal gills of mayfly larvae. — Cytobiol. *3*, 215—228.

WICHARD, W. and KOMNICK, H. (1973): Fine structural and histochemical evidence of chloride cells in stonefly larvae. 1. The coniform chloride cells. Cytobiol. 7, 297—314.

WICHARD, W., TSUI, P. T. P. and KOMNICK, H. (1973): Effect of different salinities on the coniform chloride cells of mayfly larvae. — J. Insect Physiol. *19*, 1825—1835.

Address of the author:
DR. MÁRIA CSOKNYA
Department of Zoology, A. J. University,
H-6701 Szeged, Hungary

Acta Biologica Szeged. *27* (1—4), pp. 159—168 (1981)

ZOOBENTHOS INVESTIGATIGATIONS IN THE SALINE WATERS OF THE GREAT HUNGARIAN PLAIN

MAGDOLNA FERENCZ

Department of Zoology, Attila József University, Szeged
(Received January 21. 1980)

Summary

The results of evaluation of zoobenthos investigations can be summarized in short as follows: The bottom fauna of the three natron lakes lying close enough to one another differ from one another both in quantitative and qualitative. The zoobenthos production of the bottom covered with higher vegetation close to the water-side is unambiguously higher than that of the vegetation-free bed of the lake. Desiccation is tolerated most of all by Diptera (Brachycera) larvae. The favourable light-climate influences the development of the zoobenthos positively as well. The uneven distribution of animals may be caused by the heterogenity of sediment types. 89 per cent of the investigated organisms can be found in the upper 5 cm layer of the bottom.

Introduction

The Hungarian saline waters are extremely labile ecosystems. The determining of them is their shallowness and astatic character, resulting in their considerable dependence on their neighbourhood.

The quantity and qualitative composition of their living world are determined by the annual, seasonal, daily and even diurnal fluctuation of the (abiotic and biotic) active forces.

The characteristic for the saline water benthos number of individuals — as compared with that of the similarly productive back-waters and with that of the rivers seeming to be much poorer — is to be explaned from the following data. In saline waters, in a sole sampling of a collecting cylinder of 55,5 sq · cm surface and gripping 40 cm deep, the maximum individual number was 240 (this, converted to 1 sq · m surface, mean 43,224 individuals). In the Tisza Dead Arm, the maximum individual number is 45 (8104 speciemens per sq · m) in the Tisza 25 (4502 specimens per sq · m).

Examining the saline waters of the Hungarian Great Plain, the three natron lakes respectively are the objects No.-s. 13, 14, 15, the zoobenthos fauna of which was studied by the present article. The other results, concerning the zoobenthos investigations in saline waters (Nos. 1—12), were discussed in my three papers enumerated in the list of references (1971, 1973, 1977).

The dates of collections were: 2 April, 19 May, 2 June, 17 September, 13 November 1976, 13 April, 2 June, and 3 August 1977.

On each occasion, bottom samples were taken from two biotope-types: from one site near the water-side, covered with macrovegetation and from an open-water, vegetationless site farther from the water-side. At first sampling (2 April 1976) we took one per sites qualitaive, in all the other cases with a grab one quantitative sample each.

We have investigated the three saline waters according to the following points of view.

Observation of the qualitative and quantitative distributions of the zoobenthos fauna by measuring resp. investigating into certain abiotic factors (e.g., the change in water level, desiccation, freezing of water, its translucence, composition of the sediment).

Statement of the differences between the zoobenthos of the two biotope-types.

Seasonal investigations, population-dynamic investigations.

Materials and Methods

The bottom-samples were taken with a cylindrical grab. Each of the samples means a sediment layer of 55,5 sq. cm surface and 25—30 cm depth.

Leaching the matter in the laboratory through a 0,28 mm mesh metal sieve, we picked out the animals one by one with pincers from the remainder (selection 6,3x) and then fixed them in 6 per cent formalin.

From time to time, we took samples from the two biotope-types in order to investigate into the size of sediment granules. We have investigated into the change of sediment in vertical direction, as well separating the samples into 2,5 resp. 5 cm layers. After their drying in a thermostat, and separating them with the method of hydrometry we have studied the percentage of the single fractions. Measurements were carried out in the laboratory of the Department of Geology of the Attila József University in Szeged.

The fractions fell into the following types, resp. they had the following granule-diameters:

clay	0,001—0,005 mm
clayey mud	0,005—0,02 mm
mud	0,02 —0,05 mm
muddy sand	0,05 —0,1 mm
tiny sand	0,1 —0,2 mm
middle-sized sand	0,2 —0,5 mm

Characterisation of sampling sites

Kisréti-tó

It is a saline water of about 100 hectares area being the deepest of the three investigated lakes. At sampling sites (at the east side of the lake in the middle of its longitudinal axis) the maximum water depth was 50 cm.

Macrovegetation penetrates as far as the middle of the river bed. The open water surface of the eastern side is only 1/3. of the whole lake surface.

Although at some places the bottom is covered with 30 cm thick loose silt-layer according to the data of granule-size analysis the tiny sand fraction is the largest on the bottom of the lake; its 33,2 percentage is characteristic. There is submerged vegetation (*Ceratophyllum, Chara,* green algae) on the sediment rich in detritus as well.

The water is greenish-yellow, as a rule, it is transparent as far as the bottom (measured with Secchi disk). The favourable light climate and the alga rich in organic

detritus both qualitatively and quantitatively contribute to the formation of the most luxuriant zoobenthos.

The 1706 individuals, originating from twenty samplings, are taxonomically divided as follows:

	per cent
Oligochaeta	42,8
Chironomida	18,8
Ephemeroptera	16,8
Trichoptera	11,8
Nematoda	6,1
Ceratopogonida	1,8
Diptera (Brachycera)	0,7
Hirudinoidea	0,2
Odonata	0,2
Hemiptera	0,1
Coleoptera	0,1

Investigating only the living animals (i.e. taking no notice of the Mollusca shells, the empty Trichoptera tubes and the puparia of Diptera), we have found the following individual numbers per taxon-groups:

	individuals
Oligochaeta	434
Chironomida	41
Ephemeroptera	19
Ceratopogonida	12
Diptera (Brachycera)	5
Trichoptera	4
Hemiptera	2
Odonata	1
Coleoptera	1
Nematoda	1

This quantity means the average individual number per 28,8 samples.

Comparing the material taken from the open water with that taken from the vegetation close to the waterside, it is to be established that the latter biotope is populated approximately 2 times as densely (41,1 individuals per samples) as that in the open water (22 individuals).

The individual number of species forming the zoobenthos steadily decreases from spring till autumn. This decrease is ultimately determined by the population dynamics of the dominant Oligochaeta group. The individual number of Chironomida larvae was on the other hand, higher in autumn in the bottom samples. The same applies to the Ephemeroptera larvae, as well.

The Oligochaeta fauna of the Kisréti-tó:

Naididae:

Dero obtusa UDEK. (68 individuals)
Dero digitata GRUBE (6 ind.)
Stylaria lacustris JOHNSTON (12 ind.)
Nais variabilis PIG. (10 ind.)
Chaetogaster diaphanus ORST. (5 ind.)
Allonais sp. (2 ind.)

Tubificidae:

Limnodrilus profundicola BRINKH. (231 ind.)
Limnodrilus claparedeanus RATZ. (62 ind.)
Limnodrilus hoffmeisteri CLAP. (39 ind.)
Limnodrilus sp. juv. (124 ind.)

The dominant Tubificida: *Limnodrilus profundicola,* as well as the likewise dominant Naidida: *Dero obtusa* are a-mesosaprobic organisms.

In the biotope close to the waterside Oligochaetae formed a higher percentage of zoobenthos than bottom-samples in open water.

Kelemenszék

In this astatic lake of 456 hectares area, at the sampling sites of the north-western water-side: water-depth alternated between 1 to 25 cm. But in the lake, being dried out at the time of the sampling in August 1977, only some water-side and vegetation covered sites were covered with 1 cm deep water.

The macrovegetation at the water-side is scattered. The submergible vegetation was formed by *Chara* and *Nostoc* grasses.

On the bottom a 25—30 cm thick loose silty-clayey sediment was formed, dominating — over the other sediment types — in a ratio of 39,2 per cent according to the data of investigations.

The water was troubled, its transparence changed between 2,7—7 cm.

The ratio of distribution according to the taxon groups of 822 individuals, found in the total amount of samples is:

	percentage
Oligochaeta	34,4
Nematoda	29,9
Trichoptera	14,5
Ceratopogonida	13,0
Chironomida	4,4
Coleoptera	1,7
Diptera (Brachycera)	0,8
Odonata	0,5
Ephemeroptera	0,5
Hemiptera	0,2

In the quantative samples, the quantity of living animals was formed according to taxon groups, as follows:

	individuals
Nematoda	129
Ceratopogonida	16
Oligochaeta	6
Coleoptera	6
Chironomida	5
Diptera (Brachycera)	4

The above quantity means averagely 9,2 individuals per samples. This refers to a considerably lower zoobenthos individual-number as compared with the Kisréti-tó.

Comparing the bitope covered with vegetation, close to the water-side with that of the open water the individual number of zoobenthos in the former biotope is somewhat higher (10,7 ind.) than in the later (6,8 ind.).

Nematoda, as well as Ceratopogonida, live roughly in similar individual numbers in both biotope-types. The production of the vegetation zone at the water-side is hardly higher than that of the bottom under the open water. The quantity of the individuals of these two taxon groups is similar in our saline waters and that of the plantless places respectively (FERENCZ, 1973).

The seasonal distribution of the zoobenthos in Kelemenszék is just the reverse of that in Kisréti-tó. From spring, a slight increase in the total individual number is characteristic the maximum being in autumn. This, of course, coincides with the dynamics of the population of Oligocheates, determining the quantity; the increase in the individual number of Ceratopogonida larvae in autumn is also similar to this.

The summer drying out of the lake was survived by the larvae of Brachycera, of a comparatively higher tolerance. These larvae were only found on the occasion of sampling in August 1977, from the dried out bottom of the lake.

Oligochaeta of Kelemenszék :

Naididae: *Dero digitata* GRUBE (230 ind.)
Nais sp. (3 ind.)
Tubificidae: *Isochaeta michaelseni* BRINKH. (2 ind.)
Enchytraeidae: *Pachydrilus* sp. (1 ind.)

The dominant *Dero digitata* is an a-mesosaprobic organism, found in a very large individual number in the bottom samples, taken from the biotope of the lake-side.

Zabszék

Tha saline water of 32 hectares area, the lake-side macrovegetation zone of which the broadest in the western section, but in other places, e.g. at the sampling sites (at the northern side of the lake) is comparatively negligable. The sumbergible vegetation is formed by *Chara* and *Nostoc*.

The depth of water has alternated between 15 and 40 cm. The translucence of the greyish-white, muddy water was poor, generally from 1 to 2 cm, maximum 5 cm.

The upper 15 cm of the bottom was covered with fine silty-clayey sediment. The finest fraction could be demonstrated here in 38,2 percentage.

This distribution of the 174 individuals per taxonomical groups in all the samples is, as follows:

	per cent
Ceratopogonida	34,5
Nematoda	28,2
Coleoptera	12,1
Trichoptera	7,5
Chironomida	6,9
Diptera (Brachycera)	6,3
Odonata	2,3
Acari	1,7
Oligochaeta	0,6

The quantitative data of living animals, found in 18 quantitative samples are, as follows:

	individuals
Nematoda	40
Ceratopogonida	34
Coleoptera	12
Chironomida	6
Acari	1
Oligochaeta	1
Diptera	1

The smallest individual averge t.i. 5,4 individuals was characteristic of the zoobenthos of the lake.

The biotope close to the water-side proved also to be richer here both in quantitative and in qualitative relations.

In respect of the seasonal distribution, similarly to Kelemenszék, the zoobenthos production was characterized by the maximum in autumn. This was also caused by the increase in the individual number of Nematoda and of the Ceratopogonida larvae.

In the lake, there was only found one single Tubificida in the biotope close to the water-side *(Limnodrilus hoffmeisteri)*.

It can be established according to zoobenthos investigation into our natron lakes in the Great Hungarian Plain that the dominant fauna-elements of the bottom of saline waters are the members of Chironomidae, Ceratopogonidae, resp. — in Kisréti-tó — of the Oligochaeta taxongroups.

It is remarkable that the dominance of Ceratopogonidae alternates with that of Chironomidae: the increase of the individual number in one of these groups is connected with its decrease in the other. This can be observed not only in the case of samples taken from different natron lakes but also from the same lake.

On the bottom of the eutrophic fresh waters the Tubificidae species are generally the dominant fauna-elements of the zoobenthos. Their individual density is higher in waters rich in nutritive materials (e.g., in dead arms of the Tisza).

81,8 per cent of th e Oligochaeta fauna in the Kisréti-tó are the individuals of species belonging to the Tubificidae family. The dominant species is Limnodrilus

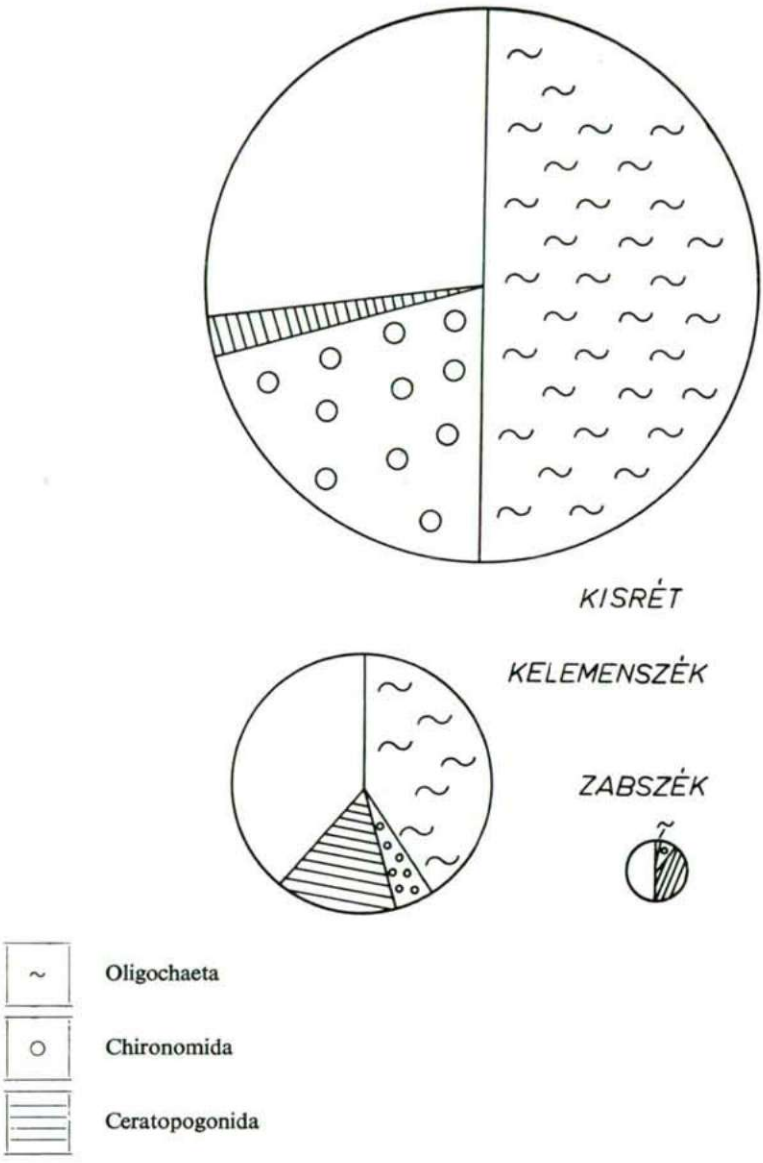


Fig. 1. The radius is in direct proportion to the individual number of zoobenthos

profundicola. Only 18,2 per cent belonged to the Naididae family. The dominant species was *Dero obtusa*. The majority of Naididae prefers the places grown over with water vegetation. In the Kisréti-tó 11,2 per cent of the Oligochaeta fauna of this

biotope while on the open-water vegetationless bottom only 4,2 per cent belonged to the Naididae species.

The distribution of animals within a biotope, according to species and individual numbers is determinated by the system of biotic and abiotic factors. The complex of factors mostly determining the zoobenthos fauna of our natron lakes is the extreme and considerable fluctuation of the waters main physiographical properties.

The decrease in water-level may have a drastic effect on the fauna on the bottom, too, particularly in shallow standing waters, even if no desiccation occurs. The surviving worms and other organinsms of the zoobenthos (e.g. Ceratopogonida and Brachycera larvae) can hide in the deeper and so still wet part of the bottom, where the tide over the unfavourable period. The possibility of survival can be ensured to the zoobenthos organisms by the deepenings in the uneven, pitted bottom of the lake, preserving water for a longer time.

The decrease in the individual number following the recession of water, e.g. in case of several Naidida species it is also explained by the decrease of the primary producent algae serving for nourishment (PFANNKUCHE, 1977).

Heterogenity is characteristic for our saline waters respect of the quality of sediment (bottom types) as well. By the data analysation of the size of granules it can be established that the sediment of the same lake can be of various types (e.g. in the Kisréti-tó the sand of small grains, in other places, on the bottom of the lake, the clayey mud was determinant). The type of sediment does not change consequently from the surface towards the deeper layer either.

Considering bottom types extreme eurytopes may be called from among Oligocheatae the majority of Limnodrilus species *(Limnodrilus hoffmeisteri, L. claparedeanus, L. udekemianus),* as well as *Tubifex tubifex.* With the refinement of sediment, the individual number of Oligochaetea rises, though the number of species shows a decreasing tendency.

In the sediment of the three saline waters, the bottom of open water was characterized by a higher percentage of sand, while the granule composition of the bottom close to the water-line can rather be characterized by the finer fraction.

The bottom of Kisréti-tó is of a sandy i.e. rougher sediment type which has been preferred by *Limnodrilus profundicola:* this fact is justified by its dominance there.

In connection with the vertical distribution of Oligochaeta, there are but few data in the literature. According to the recent investigations, it was established (PFANNKUCHE, 1977) that Tubificidae can be found in a maximum individual number at the lower border of the sediments oxidation zone.

It was observed (PFANNKUCHE, 1977) too, that in the upper sediment layer, juvenile Tubificidae are to be found in a higher number.

Naididae live generally on the surface of the sediment. The tube-dwelling Dero species are able to penetrate down deeper, but Naidida species do generally not occur deeper than 2 cm.

The maximum of the vertical distribution of Tubificidae can also be connected with these worms food requirement. In opposition to the earlier conception, they seem to consume certain (often anaerobic) bacteria or detritus selectively.

Investigating into the vertical distribution of Chironomida larvae we can establish that in our saline waters 80 per cent of the larvae dwell in the upmost sediment-

layer of 5 cm. But occasionally they are still to be found in a depth of 25—30 cm as well.

In periods of higher water the great majority of Ceratopogonida larvae live in the upper 5 cm of the sediment. In the wet or dry bottom the larvae retire deeper (15—20 cm), obviously making their escape from desiccation towards the wetter depths. This tendency characterizes both the biotopes close to the water-line and those in the middle of the bed.

It could be observed that in the samples close to the water-line taken from among the vegetation there were always comparatively somewhat more larvae in the upmost layers than in those taken from the plantless middle of the bed. This may be explained perhaps with the retarding effect of the higher vegetation of the coast close to the water-line resp. by the faster decrease in water of vegetationless places.

The sinking of water-level in natron lakes or their desiccation is an ecological factor complex strongly influencing several species. The drying up or desiccation of water and the consequent strongly changed environment (a high pH, sometimes over 10, rise in the redox-level of the mud, increased bacterial activity etc.) will only be survived by organisms which can tolerate these changes (e.g. Ceratopogonida, Brachycera). In the saline waters frozen in often to the bottom in winter the living world of the bottom is to be found, as a rule, in a comparatively lesser individual number. This can be due to the limiting effect of hydrogen sulphide, released sometimes below the ice.

The most frequent Tubificida species of Kisréti-tó are: Limnodrilus profundicola, L. claparedeanus, L. hoffmesiteri. All the three species are a-mesosaprobic organisms, and the joint occurrence of the two latter species in a higher individual number is known from hypertropic biotopes. From among these three cosmopolitan species L. profundicola the dominant species of saline waters could not be found in larger numbers in our other standing waters and in Hungarian rivers, as opposed to the other two species.

56—50 per cent of the individuals of L. profundicola collected in April and August 1976, were sexually mature. Several juvenile individuals in the samples taken in August 1977 may have belonged to this species as well. The reprodutive activity of L. claparedeanus achived its maximum in November 1976; their 33 per cent was then sexually mature.

It is worthy of note that during the same sampling the percentage of the entirely young Tubificida individuals was 75 per cent on the vegetation covered bottom close to the water-line, while in the vegetation-free biotopes farther from the water-side only 39 per cent of the worms were juvenile.

References

FERENCZ, M. (1968): Vorstudium über die vertikale Verteilung des Zoobenthos der Theiß — Tiscia (Szeged) *4*, 53—58.

FERENCZ, M. (1971): Zoobenthos Untersuchungen an ungarischen Natrongewässern — Sitzungsber. der Österr. Akad. der Wissensch. *179*, 303—306.

FERENCZ, M. (1973): Zoobenthos investigations in the saline waters of the Great Hungarian Plain — Acta Biol. Szeged. *19*, 125—137.

FERENCZ, M. (1977): Data on the vertical distribution of zoobenthos fn saline "lakes" and rivers — Acta Biol. Szeged. *33*, 108—116.
PFANNKUCHE, O. (1977): Ökologische und systematische Untersuchungen an naidomorphen Oligochaeten brackiger und limnischer Biotope — Dissertation. Hamburg 1—138.
ZAHNER, R. (1968): Biologischen Abbauvorgänge im Bodensediment von Seen — Wasser und Abwasserforschung *4*, 11—124.

Address of the author
DR. MAGDOLNA FERENCZ
Department of Zoology, A. J. University,
H-6701 Szeged, P. O. Box 428. Hungary

Acta Biologica Szeged. *27* (1—4), pp. 169—179 (1981)

MALAISE TRAP INVESTIGATIONS IN INUNDATION, SODIC AND SANDY AREAS I. QUALITATIVE RELATIONS

M. MÓCZÁR and GY. GYÖRFFY

Department of Zoology, Attila József University, Szeged

(Received September 15, 1980)

Abstract

In 5 different areas 38 000 insect specimens were collected by Malaise trap from 1972 to 1978 in 35 periods. The ratio of Diptera being predominant everywhere increases during season in flood area meadow, decreases in sandy forest and has a summer minimum in the sodic area. Among the 12 Hymenoptera superfamilies Ichneumonoides have the greatest number of species. From the 11 Macrolepidoptera families Noctuidae is the reachest in species. The species richness of flood area meadow is about 2/3 of that of sandy forest and 1/3 part of sodic areas. The number of species decreases from the spring to autumn. Cicadellidae is the most important from the 6 Cicadinea families collected and families Coccinellidae, Curculionidae and Chrysomelidae are most important among the 21 Coleoptera families collected. In a given area species similarity indices of Hymenoptera, Cicadinea and Coleoptera are highest between spring and summer but as for Lepidoptera spring-autumn Jaccard indices are the highest in inundation and sodic areas. The differences between Coleoptera, Cicadinea and Hymenoptera species communities are highest between sodic and inundation areas, but the species composition of Lepidoptera communities of these two areas is very similar. The habitat specificity of the order Hymenoptera is strongest and this is followed by Cicadinea. The specificity of Coleoptera and Lepidoptera is much less.

Introduction

The Malaise trap was published almost 50 years ago (MALAISE, 1937) but this very advantageous method has been widely used only in the last decades as an auxiliary method of faunistical investigations (e.g. KASZAB, 1966). The efficacy of this method was analysed only in certain insect groups (MARSTON, 1965; CHANTER, 1965; MÓCZÁR, 1967; GEIJSKES, 1968; MATTHEWS and MATTHEWS, 1970) because of the very huge material collected in sufficient conditions. Light traps are much more widely spread for collecting flying insects, but Malaise trap being not attractive reflects better the natural species composition (OWEN, 1969, GUNDSTREAM and CHEW, 1967). According to BREELAND and PICKARD (1965) Malaise trap is more efficient quantitatively than the other traditional methods. Other advantage of these traps is that since there is no bait in them and the animals are collected from the next environment, the material collected is clear and it can be conservated without difficulties. This method is very useful first of all to investigate in the structure of insect communities, flying activity (CLARK, 1979), seasonality, species diversity etc. (MATTHEWS and MATTHEWS, 1971).

The efficiency of Malaise trap was investigated in three types of natural conservation areas being almost at natural stage. These areas are: a flood area meadow, a sodic meadow and three sandy areas being ecologically very similar. Faunistical data were also obtained for the investigated areas.

The first step of zoological investigation of a given area is to determine the qualitative composition of the animal communities present (JERMY, 1977). Then the role of populations, their interactions and their place in the material and energy flow system can be investigated. In the course of present investigations we compared the insect communities of the areas from qualitative and relative quantitative points of view. We also studied the seasonal differences, relations between the diversity of certain insect groups and the complexity and species richness of the insect groups collected. The quantitative analysis and diversity relations will be published in an other paper. The qualitative and quantitative pecularities of the order Diptera will be discussed separately, too.

Study sites

Körtvélyes: An isle situated between 201st and 204th river kms of River Tisza surrounded by the river and a dead arm of the Tisza. It is flooded almost every year. The vegetation is hygrophilous. Malaise trap were placed on the central meadow. Its plant associations are as follows: *Alopecuretum pratensis; Carici-Typhoidetum arundinaceae; Glycerietum maximae* (ANDÓ, BODROGKÖZY and MARIÁN, 1974). The arboricole species lives in the surrounding woods: *Salicetum triandrae, Salicetum albae-fragilis populetosum* and *Ulmo-Fraxinetum* that are at least 200 m from the place of the trap. "The surface of the water of large mass has an extreme modifying effect on climate. The annual cloud formation is here the smallest in the country. The degree of average cloudiness of the month August is lower than 35 percent (ANDÓ, 1958, 1959).

Kiskundorozsma: ("dorozsmai nagyszék", abbreviation: D): It is a solontschak sodic meadow situated near Szeged town. The solontschak flat is bordered by a small "brown sand" dune that is covered by Potentillo-Festucetum pseudovinae plant association. The main types of the plant associations forming a mosaic-like pattern on the solontschak flat are: *Lepidio-Camphorosmetum* annuae and *Lepidio-Puccinellietum limosae.*

Ásotthalom: It is about 30 km west of Szeged. The trap was placed into a clearing of the so-called "Kiss Ferenc Memory Wood" being a natural conservation area. The plant associations of this sandy soil area are: *Festuco-Quercetum populatosum albae, Festucetum vaginatae danubiale* and *Astragalo-Festucetum rupicolae* (BODROGKÖZY, 1957).

Fülöpháza: The trap was placed in an area of the Kiskunság National Park, that is about 20 km west of Kecskemét town, where some areas of different types meet. One of them is a pasture with *Artemisio-Festucetum pseudovinae lepidietosum* association the other is a little salt lake with *Lepidio-Camphorosmetum* annuae and *Lepidio-Puccinellietum limosae* vegetation in its shore. About 400 m NW of the trap there was a sand dune with xeromorphic vegetation its basic association is *Potentillo-Festucetum pseudovinae* (BARANYAI, G., 1979, manuscript). There were also a rye field in east direction. Only few collections were made here.

Bugacpuszta: It also belongs to Kiskunság National Park. The trap was in the centre of a 2 ha area without grazing activity. The area is a typical mosaic complex that consists of wind furrows and small sand dunes. The typical plant association is *Festucetum vaginatae* on the dunes and *Molinio-Salicetum rosmarinifoliae* in wind furrows. The grassland is bordered by wood stand that is about 100 m from the place of the trap. It is characteristical for the microclimate of this area that the annual precipitation is much less than the country average and the fluctuations in temperature are very strong.

Methods

The original Malaise trap (GRESSITT and GRESSITT, 1962, TOWNES, 1962) was modified by MÓCZÁR (1967) and this modified type was used. Samples were taken generally three times a year (spring, summer and autumn). The traps were emptied every day in morning hours (9—10 a.m.). The time data of the collections are as follows:

Körtvélyes:
Spring: 7—12 June 1972; 21—26 June 1973; 2—6 June 1974.
Summer: 18 July—08 August 1972; 18—23 July 1973.
Autumn: 10—13 Oct. 1972; 23—27 Sept. 1975.

Kiskundorozsma:
Spring: 6—12 June, 1972; 13—18 June 1973; 15—19 June 1974; 17—20 June 1975.
Summer: 9—11 July. 1972; 26 July—08 August 1973; 30 July—08 August 1974; 25—28 August 1975.
Autumn: 21—29 Sept. 1972; 19—25 Sept. 1974; 24—27 Sept. 1975.

Ásotthalom:
Spring: 29 May—06 June 1972; 30 June—06 July 1973; 31 May—06 June 1974; 21—27 June 1975.
Summer: 18—25 July 1972; 2—7 August 1973; 6—11 August 1974; 21—24 August 1975.
Autumn: 18—20 Oct. 1972; 8—18 Oct. 1974; 18—21 Sept. 1975.

Fülöpháza:
12—16 July 1977; 3—8 June 1978; 2—8 August 1978; 1—6 Sept. 1978.

Bugacpuszta:
16—23 June 1976; 31 August—6 Sept. 1976. As for meteorological factors the influences of the cold and warm fronts were evaluated but significant correlation wasn't found.

Elaborating the collected materials the main orders, Hymenoptera, Macrolepidoptera, Cicadinea and Coleoptera were identified on species level.

For the qualitative characterization of areas or time aspects we used the number of families and their species richness. To compare different areas and seasons Jaccard's index was used:

$$J_a = \frac{c}{a+b-c}$$

where a = number of species in sample A; b = number of species in sample B and c = number of species common to samples A and B.

Results

In the course of trappings altogether 37,763 insect specimens were collected, 8170 in the flood area at Körtvélyes, 8065 in the sodic area at Kiskundorozsma and 7581 at Ásotthalom. 8990 specimens were collected by the trap at Fülöpháza, but 86 p.c. of that was Diptera species and most of them Nematocera owing to the sodic lake.

Among the insects collected the order Diptera was predominant at every place (Fig. 1). On the humid flood area meadow and in sodic areas the ratio of Diptera was

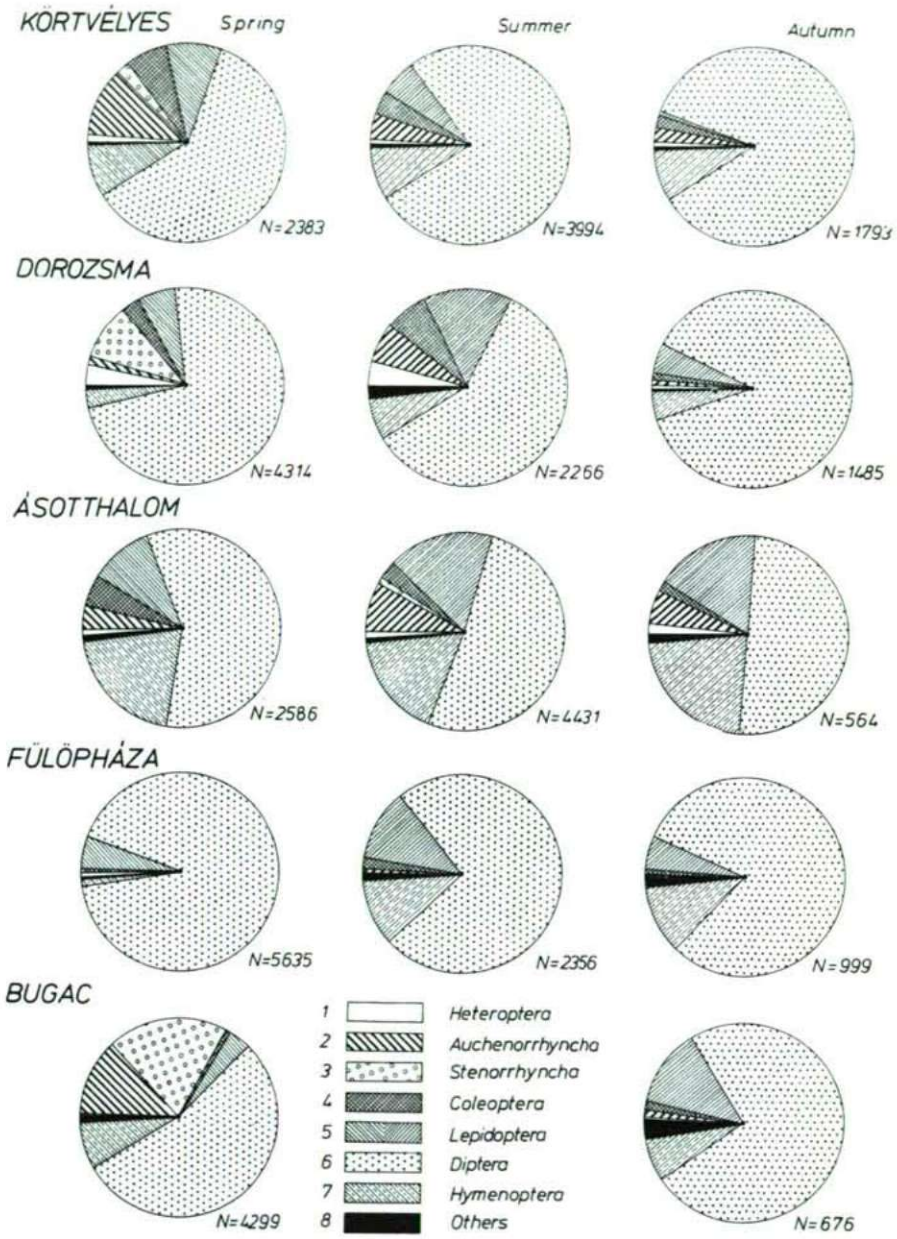


Fig. 1. Seasonal and local specimen distribution of the orders drawing together the data from 1972 to 1978 (N = number of specimens).

72 p.c. because of the temporary water coverage, but it was only 54—56 p.c. in sandy areas. In spring, summer and autumn periods the dominancy is different within the single areas. For instance from spring to autumn in the flood area it increases from 53 up to 86 p.c. In the sodic areas it is the lowest in summer (58 p.c.), higher in spring (73 p.c.) and in autumn it can reach 87 p.c. In the sandy areas of Ásotthalom the dominancy of Diptera slightly decreases (58—49 p.c.) during season.

Hymenoptera (11 p.c.), Cicadinea and Lepidoptera (6—6 p.c.) are subdominant groups in the flood area. In the sodic area Lepidoptera (9 p. c.), Sternorrhyncha (5 p.c.) and Hymenoptera (4 p. c.) are subdominant but the the quantity of Coleoptera, Heteroptera and Cicadinea has also a certain significance (3 p.c.). In the sandy areas subdominants are: Hymenoptera (19 p.c.), Lepidoptera (15 p.c.) and Cicadinea (7 p.c.).

The following orders signed as "others" were represented in significantly less quantity in the Malaise trap: Ephemeroptera, Odonata, Blattodea, Orthoptera, Neuroptera. For details see Figure 1.

Hymenoptera

The total amount of Hymenoptera specimens is the second biggest after Diptera except for the sodic area. None of the superfamilies were limited to one of the three aspects. Ichneumonoides proved to have most species in every period and area (Table 1). The number of Ichneumonoide species was the greatest in spring, decreased to

Table 1. Superfamily distribution of Hymenoptera species

Superfamilia	Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac	
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au
1. Tenthredinoidea	10	18	6	1	2	2	2	4	3	—	2	1	—	1
2. Ichneumonoidea	108	70	64	34	49	13	69	62	31	?	?2	?	87	7
3. Cynipoidea	—	—	—	—	—	—	2	—	—	—	—	—	—	—
4. Chalcidoidea	1	1	2	—	—	—	—	8	—	—	2	1	1	1
5. Proctotrupoidea	—	—	2	1	—	—	2	—	—	—	—	—	1	1
6. Chrysidoidea	3	—	—	—	—	—	1	2	—	2	4	1	—	—
7. Scolioidea	1	1	—	—	—	—	2	2	—	—	1	1	7	1
8. Formicoidea	—	1	1	1	1	—	4	3	1	—	1	—	2	1
9. Pompiloidea	3	3	—	8	4	—	9	19	2	—	2	—	1	1
10. Vespoidea	2	2	—	2	1	—	4	5	3	—	1	4	1	—
11. Sphecoidea	9	19	2	6	15	—	21	31	7	2	18	1	21	2
12. Apoidea	10	21	—	11	11	—	18	40	1	—	11	1	27	1
Sum total:	147	136	77	64	83	15	134	175	48	?4	?44	?10	148	16

summer and had a minimum in autumn. In the sodic area the number of species was less in spring than in summer, that fact might be a result of the long-lasting water coverage. In sandy areas the ratio of Sphecoidea and Apoidea was considerable. The number of Sphecoidea species had summer maxima at all localities. The Apoidea species were similar except sodic areas where the flower level is poor in species and soil has unsuitable nesting possibilities. The number of Pompiloidea is very high in the sandy area at Ásotthalom, which is very suitable biotop for them. In the flood

area meadow the number of Tenthredionoidea species is about 4 times higher than in other areas because that humid environment is very advantageous for their development.

It can be seen from the very low values of species similarities (Table 2) that there are considerable differences between different aspects of an area, because the majority of adult Hymenoptera have very short life span. It is conspicuous in the sodic area where there is no similarity between spring and summer periods.

Table 2. Species similarity values for Hymenoptera between areas and aspects

Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac			
Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au		
100	8.15	3.13	2.85			4.74			0.00			3.07		Sp	
	100	2.84		5.52			4.88			2.24				Su	K
		100			0.00			3.17			0.00		0.00	Au	
			100	6.20	0.00	7.89			0.00			3.34		Sp	
				100	3.06		5.11			4.80				Su	D
					100			0.00			0.00		3.22	Au	
						100	9.69	2.87	0.76			6.59		Sp	
							100	5.02		7.90				Su	Á
								100			1.75		3.22	Au	
									100	2.12	7.14	0.66		Sp	
										100	3.77			Su	F
											100		0.00	Au	
												100	1.24	Sp	
													100	Au	B

Comparing the whole year faunas of the different areas (Table 3) it can be established that the similarity of species composition is almost identical on a lower level.

Comparing the same aspects of different areas (Table 2) it can be seen that the similarity is least in autumn and only a little similarity could be found between Ásotthalom and the flood area. The similarity of summer faunas is just below 5 p.c. and that of autumn is very different (3—8 p.c.).

Table 3. Species similarity of Hymenoptera between areas

K	D	Á	F	B	
100	6.76	6.79	2.36	4.12	K
	100	8.59	4.47	6.53	D
		100	7.20	8.58	Á
			100	7.51	F
				100	B

Table 4. Species similarity of Macrolepidoptera between areas

K	D	Á	F	B	
100	17.91	13.39	7.04	6.34	K
	100	14.85	8.33	5.76	D
		100	9.52	7.21	Á
			100	10.71	F
				100	B

Lepidoptera

After Diptera, Lepidoptera means together with Hymenoptera the second-third most important orders. Although Microlepidoptera represented 60—80 p.c. of the order they were not identified on species level because of the determination difficulties of this group. Otherwise the number of Macrolepidoptera specimens and species is great enough to be evaluated.

From the families collected (Table 5) it can be established that Noctuides have the highest species richness in every aspect. There were also many Geometridae, Satyridae and Pieridae species. Cossidae, Notodontidae and Sphingidae were collected only in spring, Hesperidae, Lycaenidae and Nymphalidae mostly in summer. The majority of Lepidoptera species were collected in sandy areas, in flood area 60—65, in sodic area only about 30 p.c. of them were cought. The widest species spectrum was measured in summer period and the poorest was the autumn fauna at all places.

Table 5. Family distribution of Macrolepidoptera species

Familia	Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac	
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Su	Au
1. Hepialidae	—	—	—	—	—	—	—	—	—	—	—	1	—	—
2. Cossidae	—	—	—	1	—	—	—	—	—	—	—	—	—	—
3. Notodontidae	—	—	—	—	—	—	1	—	—	—	—	—	—	—
4. Noctuidae	8	13	1	6	11	1	15	20	5	6	8	12	5	7
5. Geometridae	—	5	—	—	2	—	8	16	2	—	1	5	2	3
6. Sphingidae	—	—	—	—	—	—	1	—	—	—	—	—	—	—
7. Hesperidae	—	3	—	—	—	—	1	2	—	—	1	—	1	2
8. Pieridae	2	4	—	2	4	1	1	3	1	—	3	1	—	—
9. Lycaenidae	—	2	—	—	1	—	1	1	—	1	1	—	—	—
10. Nymphalidae	—	1	—	—	2	—	1	3	—	—	—	—	—	—
11. Satyridae	2	4	—	3	1	3	4	8	3	—	1	1	3	2
Sum total:	12	32	1	12	21	5	33	53	11	7	15	20	11	14

The species identity indeces are high (11—24 p.c.) between different periods of a given area, in the sodic and sandy areas the spring and autumn faunas are most similar, probably because of the multivoltine species. In the flood area in autumn only one species represented the order Lepidoptera and it differed from all species having lived there in spring and summer.

Comparing the different places in yearly relations it can be seen that the fauna collected at Fülöpháza has only a very weak similarity to the others except Bugac (Table 4). The Lepidoptera communities of the sodic and flood areas are very near to each other. On the basis of the similarity indices the species composition of the inundation area is most related to that of sodic area (25 p.c.) in spring and it differs most from the fauna of Fülöpháza. The fauna of sodic area is similar to the inundation area in spring and summer and to Ásotthalom in autumn. The fauna of Ásotthalom is most similar to the inundation area in spring and summer and to the sodic area in autumn (Table 6).

Table 6. Local and seasonal species similarity of Macrolepidoptera

Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac			
Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au		
100	13.63	0.00	25.00			13.33			0.00			4.34		Sp	
	100	0.00		16.98			12.94			10.63				Su	K
		100			0.00			0.00			0.00		0.00	Au	
			100	18.18	23.52	11.11			0.00			4.34		Sp	
				100	11.53		12.16			8.33				Su	D
					100			18.75			0.00		0.00	Au	
						100	17.44	13.63	2.50			2.27		Sp	
							100	10.93		5.88				Su	Á
								100			6.45		8.00	Au	
									100	18.18	11.11	5.55		Sp	
										100	11.42			Su	F
											100		11.76	Au	
												100	4.00	Sp	B
													100	Au	

Cicadinea

Cicadinea is a trophically homogeneous group and it depends strongly on the host-plant relations and plant associations. This fact must be seen in the material collected by Malaise trap.

Family Cicadellidae is the richest in species in all aspects and areas (Table 7). Delphacidae and Cercopidae are also constant families but they have very few species in the areas investigated. The number of species is generally similar in spring and summer and the fewest species can be found in autumn. The sodic area is an exception because it has a summer maximum in species richness probably because of spring water coverage. The situation is different in the inundation area owing to the arboricolous species living there.

The species similarity (Table 8) is highest between spring and summer periods (23—26 p.c.). It is 18—23 p.c. between spring and autumn and 13—17 p.c. between summer and autumn.

Table 7. Family distribution of Cicadinea species

Familia	Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac	
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au
1. Achilidae	—	—	—	—	—	—	1	1	—	—	—	—	—	—
2. Cercopidae	2	1	1	1	1	1	4	1	1	1	1	—	2	1
3. Cicadellidae	14	11	8	9	19	4	15	17	10	9	6	1	14	4
4. Cixiidae	—	—	—	2	2	—	1	—	—	—	2	—	—	—
5. Delphacidae	1	2	—	1	3	1	2	1	2	—	1	1	2	1
6. Dictyopharidae	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Sum total:	17	14	9	14	25	6	23	20	13	10	10	2	18	6

Table 8. Seasonal similarity of Cicadinea species

	Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac	
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au
Sp	100	22.58	19.23	100	23.07	15.00	100	25.58	13.88	100	10.00	0.00	100	8.33
Su		100	17.39		100	12.90		100	15.15		100	0.00		
Au			100			100			100			100		100

The qualitative similarity between the areas in annual relations is shown in the Table 9. Since the differences are great between the areas the species similarity is low. It is caused by the psammophile species at Ásotthalom, Bugac and Fülöpháza and by the arboricolous species at Ásotthalom and the inundation area.

Table 9
Species similarity of Cicadinea between areas

K	D	Á	F	B	
100	13.79	12.50	17.39	14.58	K
	100	9.85	15.38	7.40	D
		100	15.25	13.11	Á
			100	9.52	F
				100	B

Table 10
Species similarity of Coleoptera between areas

K	D	Á	F	B	
100	17.47	16.49	12.85	7.14	K
	100	15.00	19.17	6.84	D
		100	20.89	11.94	Á
			100	15.00	F
				100	B

Coleoptera

Coleoptera takes only 5—6 p.c. of the total material collected and the species belonging to this order have inhomogeneous trophic pecularities but since the apperent differences in family and species richness can be characteristical for the areas investigated it is worth analysing this group in details (Table 11).

Characteristical families were in spring: Elateridae, Cantharidae, Dasytidae, Mordellidae, Melolonthidae and Lampyridae. Cerambycidae is the only typical summer family, but there is no any being characteristical for autumn. Families Coccinellidae, Curculionidae, Chrysomelidae and Carabidae being richest in species are represented in all aspects. Spring and summer species richness values are similar and the fewest species can be found in autumn.

18—23. p.c. similarity can be seen between spring and summer periods (Table 12). The similarity between spring and autumn is only 5—12 and between summer and autumn 3—8 p.c. only. The considerable similarity between spring and autumn may reflect two generations.

Comparing different areas (Table 10) the species similarity is generally 13—21 p.c. with the exception of the data originated from Bugac. The values of similarity indices at Bugac are about 7 p.c. because summer samples were not taken there.

Investigating the species similarity indices according to periods (Table 12) it turns out that these values are more extreme. The greatest differenes are in spring,

Table 11. Family distribution of Coleoptera species

Familia	Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac	
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au
1. Alleculidae	—	1	—	—	—	—	1	1	—	—	—	—	—	—
2. Buprestidae	—	—	—	—	—	—	1	1	—	—	—	—	1	—
3. Cantharidae	2	—	—	1	—	—	—	—	—	—	—	—	—	—
4. Carabidae	—	3	5	5	14	—	1	—	—	—	—	—	—	2
5. Cerambycidae	—	—	—	—	—	—	—	1	—	—	1	—	—	—
6. Chrysomelidae	4	5	1	—	2	—	4	3	—	3	2	—	2	—
7. Coccinellidae	5	8	2	7	10	2	5	8	2	1	7	2	1	2
8. Curculionidae	5	2	2	2	1	1	4	4	1	—	2	—	2	—
9. Dasytidae	1	—	—	1	—	—	1	—	—	—	—	—	—	—
10. Dermestidae	—	—	1	—	1	—	—	—	—	—	—	—	—	—
11. Elateridae	2	1	—	1	3	—	2	1	—	—	—	—	1	—
12. Lagriidae	—	—	—	—	—	—	1	1	—	1	1	—	1	—
13. Lampyridae	—	—	—	1	—	—	1	1	—	—	—	—	—	—
14. Malachiidae	3	2	—	2	1	—	—	—	—	—	2	1	1	—
15. Meloidae	—	—	—	1	—	—	—	—	—	—	1	—	1	—
16. Melolonthidae	—	—	—	2	—	—	3	3	—	—	1	—	5	1
17. Mordellidae	1	—	—	1	—	—	1	2	—	—	—	—	1	—
18. Mylabridae	—	1	—	—	—	—	—	—	—	—	—	—	—	—
19. Oedemeridae	3	2	—	—	—	—	4	2	—	—	—	—	—	—
20. Phalacriidae	—	—	—	—	1	—	1	—	—	—	—	—	—	—
21. Staphylinidae	2	—	1	1	1	—	1	1	—	—	—	—	—	—
Sum total:	28	27	12	28	35	3	31	29	3	5	17	3	16	5

Table 12. Similarity of Coleoptera species

Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac			
Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au		
100	18.18	10.00	17.85			8.47			3.12			4.54		Sp	
	100	7.69		17.74			14.28			20.45				Su	K
		100			13.33			13.33			13.33		0.00	Au	
			100	19.04	6.45	11.86			3.03			4.54		Sp	
				100	7.89		10.93			15.38				Su	D
					100			16.66			33.33		12.50	Au	
						100	23.23	5.88	11.11			10.63		Sp	
							100	3.12		21.73				Su	Á
								100			33.33		12.50	Au	
									100	18.18	12.50	9.52		Sp	
										100	15.00			Su	F
											100		12.50	Au	
												100	4.76	Sp	B
													100	Au	

smaller in summer and in autumn they increase in some areas (sodic area — sandy area, Fülöpháza — Ásotthalom, Fülöpháza — sodic area) or decrease elsewhere (inundation area — sandy area, inundation area — sodic area, inundation area — Fülöpháza relations). The inundation area and sodic meadow have qualitatively most differenciated Coleoptera fauna.

References

ANDÓ M. (1958): A Tisza-ártér mikroklima hatásainak eredményei (Results of microclimatical effects of the flood area of river Tisza). — Acta Geogr. Szeged. *4*, 3.

ANDÓ M. (1959): Mikroklima sajátosságok a Tisza-ártér déli szakaszán (Pecularities of microclimate in the southers part of the flood area of river Tisza). — Földr. Ért. *8*, 309—336.

ANDÓ M., BODROGKÖZY GY. és MARIÁN M. (1974): A Mártély—Sasér Tájvédelmi Körzet társadalmi hasznosításának biológiai és természeti földrajzi alapjai (Biological and physicogeographical foundations of the social exploitation of the Mártély—Sasér Region Conservation District). — Manuscript, a Competition Essay.

BARANYAI G. (1979): Gyepökoszisztémák repülő rovarközösségeinek összehasonlító vizsgálata (Comparative investigations in insect communities of grassland ecosystems). — Manuscript.

BODROGKÖZY, GY. (1957): Die Vegetation der Weispappel-Haine in dem Reservat "Emlékerdő" bei Szeged—Ásotthalom. — Acta Biol. Szeged. *3*, 127—140.

BREELAND, S. G. and PICKARD, E. (1965): The Malaise trap — an efficient and unbiased mosquito collecting device. — Mosquito News *25*, 19—21.

CHANTER, D. O. (1965): The Malaise trap. — Entomol. Rec. *77*, 224—226.

CLARK, J. T. (1979): Psocoptera activity as monitored by a Malaise trap. — Entomol. Monthly Mag. *114*, 94—95.

GEIJSKES, D. C. (1968): Insect collecting in Suriname with the help of "Malaise" traps. In: Studies on the fauna of Suriname and other Guyanas, no. 39. — Natuurwetensch. Studierking Suriname Ned Antillen *18*, 101—109.

GRESSITT, J. L. and GRESSITT, M. K. (1962): An improved Malaise trap. — Pacific Insects *1*, 87—90.

GUNSTREAM, S. E. and CHEW, R. M. (1967): A comparison of mosquito collecting by Malaise and miniature light traps. — J. Med. Entomol. *4*, 495—496.

JERMY T. (1977): A szárazföldi ökoszisztémák hazai kutatásának néhány kérdéséről (On some problems of terrestrial ecosystem research in Hungary). — MTA Biol. Oszt. Közl. *20*, 447—450

KASZAB, Z. (1966): Ergebnisse der zoologischen Forschungen von der Dr. Z. Kaszab in der Mongolei 107. Liste der Fundorte der IV. Expedition. — Folia Ent. Hung. *19*, 559—620.

MALAISE, R. (1937): A new insect-trap. — Entomol. Tidskrift *58*, 148—160.

MARSTON, N. (1965): Recent modification in the design of Malaise insect traps with a summary oJ the insects represented in collections. — J. Kansas Entomol. Soc. *38*, 154—162.

MATTHEWS, R. W. and MATTHEWS, J. R. (1970): Malaise trap studies of flying insects in a New York mesic forest. I. Ordinal composition and seasonal abundance. — J. N. Y. Entomol. Soc. *67*, 52—59.

MATTHEWS, R. W. and MATTHEWS, J. R. (1971): The Malaise trap: its utility and potential for sampling insect populations. — The Michigan Entomol. *4*, 117—122.

MÓCZÁR, L. (1967): Trap automatic for capture of flying insects. — Folia Entomol. Hung. *20*, 213—221.

OWEN, D. F. (1969): Species diversity and seasonal abundance in tropical Sphingidae (Lepidoptera). — Proc. R. Entomol. Soc. London (A) *44*, 162—168.

TOWNES, . (1962): Design for a Malaise trap. — Proc. Entomol. Soc. Wash. *64*, 253—262.

Address of the authors:
Prof. Dr. L. MÓCZÁR
Dr. GY. GYÖRFFY
Department of Zoology, A. J. University,
H—6701 Szeged, P. O. Box 428. Hungary

Acta Biologica Szeged. 27 (1—4), pp. 181—193 (1981)

MALAISE TRAP INVESTIGATIONS IN INUNDATION, SODIC AND SANDY AREAS II. QUANTITATIVE RELATIONS

GY. GYÖRFFY and L. MÓCZÁR

Department of Zoology, Attila József University, Szeged

(Received September 15, 1980)

Abstract

In five different areas 38 thousand insect specimens were collected by Malaise trap from 1972 to 1980 in 35 time periods. From the order Hymenoptera the most important group superfamily is Ichneumonoidea at all localities. In the inundation meadow Tenthredinoidea and on the sandy and sodic grasslands Sphecoidea, Pompiloidea and Apoidea are also important. From Lepidoptera families dominant groups are: Noctuidae, Hesperidae and Lycaenidae in inundation area, Satyridae and Pieridae in sandy areas, Satyridae, Noctuidae and Nymphalidae in sodic areas. Among Cicadinea families Cicadellidae, Delphacidae and Cercopidae are important. In the sodic area Cixiidae is frequent, too. Coccinellidae is the dominant group at all localities from the 21 Coleoptera families collected. In addition to it Curculionidae in autumn, Melolonthidae and Chrysomelidae in spring are important. According to Renkonen's index Hymenoptera communities of inundation and sodic areas are most specific in spring. In summer the identity indices of species dominance are similar. In the sandy areas Lepidoptera species characteristic to seasons are more important than elsewhere. Seasonal differences in the Lepidoptera fauna are least in the sodic area. The biotop specificity of Cicadinea fauna is high according to Renkonen's indices. The differences between Coleoptera communities of the sites investigated are highest in spring. Order Hymenoptera has the highest species diversity because of the great number of them. The eveness of Hymenoptera population is highest on sodic meadow. The diversity and species richness of Lepidoptera is high in woody areas. The eveness is higher in summer in the inundation area and in spring in sodic and sandy areas. The diversity of Cicadinea living in grasslands is higher than in woodlands. The diversity and eveness of Coleoptera are nearly identical at all localities.

Introduction

No paper has been found conserning total material collected by Malaise trap and there are only very few authors who elaborated even some details of Malaise trap materials (MARSTON, 1965; CHANTER, 1965; MÓCZÁR, 1967; GEIJSKES, 1968; MATTHEWS and MATTHEWS, 1970, 1971). The whole collected material cannot be evaluated in the frame of one paper, so we have separately published the qualitative relations of the flying insect communities of the areas investigated (MÓCZÁR and GYÖRFFY, (1981). Present paper discusses the quantitative relations and seasonal diversity of these populations. The investigations were made in 5 different sites being natural and conserved areas. The most important areas are: inundation area (Körtvélyes), sodic meadow (Kiskundorozsma=D) and a sandy woodland (Ásotthalom). Additional investigations were performed: sandy grassland (Bugacpuszta), a pasture with loess and sodic soil (Fülöpháza) (MÓCZÁR and GYÖRFFY, 1981).

Methods

The sampling program and periods are described in MÓCZÁR and GYÖRFFY (1981). Malaise trap (Malaise, 1937) improved by MÓCZÁR (1967) was used in three periods yearly from 1972 to 1978. Samples were taken altogether 35 times. The exact sample program was detailed in the previous paper (MÓCZÁR and GYÖRFFY, 1981).

Analysing the fauna of areas and time periods from quantitative points of view we investigated in the p.c. dominance of families and Renkonen's index of similarity:

$$PS = \sum_i \min (p_{1i}\, p_{2i})$$

where PS is the similarity between the communities being analysed, p_{ji} is the p.c. ratio of the ith species in the jth sample.

Shannon-Weawer formula was used to estimate species diversity

$$H = -\sum_i p_i \ln p_i,$$

where H is the diversity, p_i is the proportion of the number of individuals of the ith species in the community.

Results

Hymenoptera

From the Hymenoptera superfamilies (Fig. 1) Ichneumonoidea has the highest number because of the considerable species richness of this group. This was also established by MÓCZÁR (1967). Superfamilies Chalcidoidea and Proctotrupoidea having otherwise also many species represent only a very low ratio in the Malaise collection because of their small size and unfrequent flying activity. The same was found in wet biotops of inundation area and in summer and autumn period in sodic meadow, as well. On sandy grassland the high number of Apoidea species was also remarkable. The majority of Ichneumonoidea among Hymenoptera speciments collected at Fülöpháza is caused by the heterogeneous environment and not by the sandy soil.

Comparing the quantity of Hymenoptera families of 3 area types it can be concluded that in addition to Ichneumonoidea the amount of Tenthredinoidea specimens is also big in the wet inundation meadow with dense vegetation. In relation to other superfamilies the number of Apoidea and Sphecoidea species was increased by the dense flower layer in spring and summer. This considerable number of species strongly decreased after flowering.

The number of parasite Ichneumonoides is has become dominant only in sodic areas, the role of Tenthredinoidea is minimal because of the open and drier character of the biotop. The number of Pompiloidea and Sphecoidea increased because of the low vegetation and flowers but they were outnumbered by flower visiting Apoidea in spring and summer. In autumn only Ichneumonoides were predominant and also Vespides were more frequently captured than earlier because their number had increased owing to the social way of life.

In sandy areas Aculeata, especially Apoidea and Formicoidea were dominant, Ichneumonoidea are subdominant as parasites of the former groups. Relations are similar in summer. In autumn Apoidea species were dominant owing to the fact men-

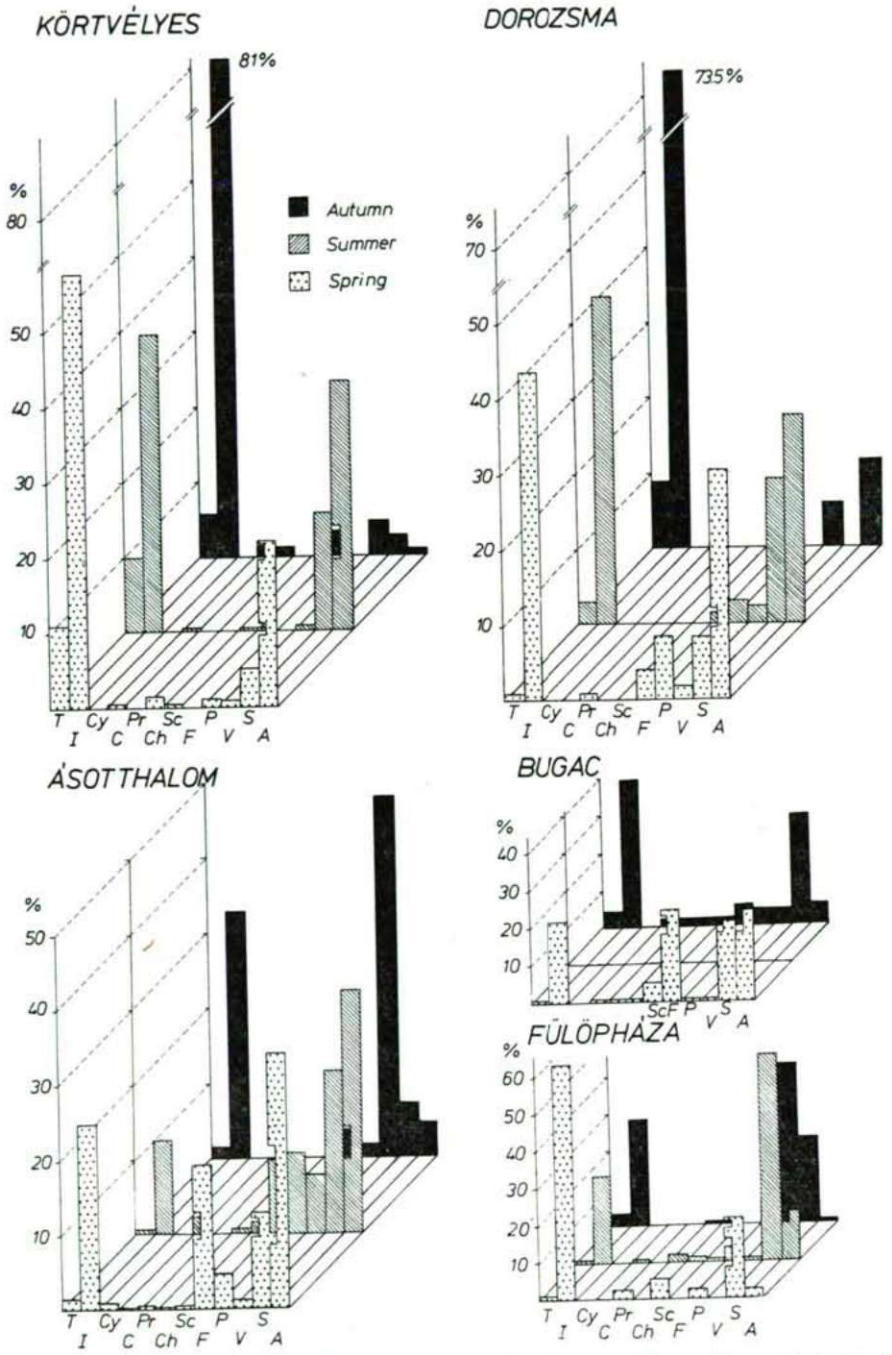


Fig. 1. Quantitative distribution of Hymenoptera superfamilies according to time periods. T = Tenthredinoidea, I = Ichneumonoidea, Cy = Cynipoidea, C = Chalcidoidea, Pr = Proctotrupoidea, Ch = Chrysidoidea, Sc = Scolioidea, F = Formicoidea, P = Pompiloidea, V = Vespoidea, S = Sphecoidea, A = Apoidea.

Table 1. Values of Renkonen's similarity indices of Hymenoptera species according to aspects and areas

Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac			
Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au		
100	16.52	7.19	10.29			6.86			0.00			4.79		Sp	
	100	4.58		11.21			8.55			5.25				Su	K
		100			0.00			2.67			0.00		0.89	Au	
			100	7.84	1.33	14.36			0.00			3.46		Sp	
				100	6.86		8.05			12.18				Su	D
					100			0.00			0.00		3.84	Au	
						100	22.79	5.20	1.19			17.87		Sp	
							100	9.83		18.15				Su	Á
								100			0.00		3.32	Au	
									100	16.66	25.00	2.32		Sp	
										100	17.48			Su	F
											100		0.00	Au	
												100	2.71	Sp	
														Su	B
													100	Au	

tioned above, Ichneumonoides were subdominant and the species of other families became rare.

The similarity of species dominance (Renkonen's index) is several times higher than Jaccard index (MÓCZÁR and GYÖRFFY, 1981) between different periods in the same areas (Table 1). So the dominant species have probably more than one generations, social way of life or longer life span. Dominance similarity is highest between spring and summer least between spring and autumn, for instance in sandy areas similarity between spring and summer is 23 p.c., between summer and autumn 10 p.c. and between spring and autumn 5 p.c.

Comparing different areas it can be experienced that the similarity of species dominance (Table 2) is generally twice as high as species similarity.

Table 2. Values of Renkonen's indices of Hymenoptera species according to areas in annual relations.

Table 3. Values of Renonen's index of similarity in the Macrolepidoptera species according to time periods in annual relations

Table 2

K	D	Á	F	B	
100	12.71	10.67	3.09	6.98	K
	100	14.71	8.84	10.84	D
		100	16.98	19.07	Á
			100	18.20	F
				100	B

Table 3

K	D	Á	F	B	
100	35.04	23.38	10.80	4.53	K
	100	27.21	9.27	4.09	D
		100	10.55	5.45	Á
			100	11.49	F
				100	B

Investigating in this in different periods (Table 1) it can be established there are common species only in the fauna of the flood and sandy areas in autumn and it is only 3 p.c., so the quantitative similarity and Renkonen's index are very low. It is about the same in summer period. In spring the fauna of flood area is most differentiated and it is followed by sodic and sandy areas respectively.

Lepidoptera

Investigating in the quantitative relations only of Macrolepidoptera families by collection areas and time periods (Fig. 2) it emerges that in spring family Satyridae is predominant in sandy and sodic sites (40 p.c.), while in the flood area Pieridae has the highest ratio (39 p.c.) closely followed by Noctuidae (35 p.c.). Besides the two dominant families, Noctuidae and Satyridae, Geometridae is also important in sandy areas, while in inundation and sodic areas Pieridae is the most important family. In the sandy area at Ásotthalom the ratio of Satyridae increases from 41 to 65 p.c. during season, it decreases in the flood and sodic areas. In the inundation area Hesperidae is the dominant and Lycaenidae is subdominant in summer. This is the most diversified aspect when six families have important role comparing the other areas' with maximum four.

In the sodic area Nymphalidae has also certain role (6 p.c.) but Noctuidae and Satyridae are the most important families here as well. In the sandy area Pieridae is also important in summer (15 p.c.) but neither in spring nor in autumn. The autumn aspect like summer ones do differ from each other. In the inundation area Noctuidae, in sodic area Pieridae and in sandy area Satyridae are dominant in autumn.

Besides quantitative relations of families comparing the faunas of different periods or areas we got the following results. Between different aspects of the same areas Ta ble 4) Renkonen's index is higher than Jaccard's index in the inundation and sodic

Table 4. Values of Renkonen's indices of Lepidoptera species according to areas and time periods

Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac			
Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au		
100	24.02	0.00	42.39			23.80			0.00			4.76		Sp	
	100	0.00		19.40			18.10			11.52				Su	K
		100			0.00			0.00			0.00		0.00	Au	
			100	37.57	30.36	27.60			0.00			4.76		Sp	
				100	13.63		14.31			7.72				Su	D
					100			15.60			0.00		0.00	Au	
						100	14.82	22.19	1.19			4.76		Sp	
							100	12.30		4.81				Su	Á
								100			7.57		9.29	Au	
									100	16.02	12.04	4.76		Sp	
										100	10.65			Su	F
											100		22.32	Au	
												100	2.32	Sp	
														Su	B
													100	Au	

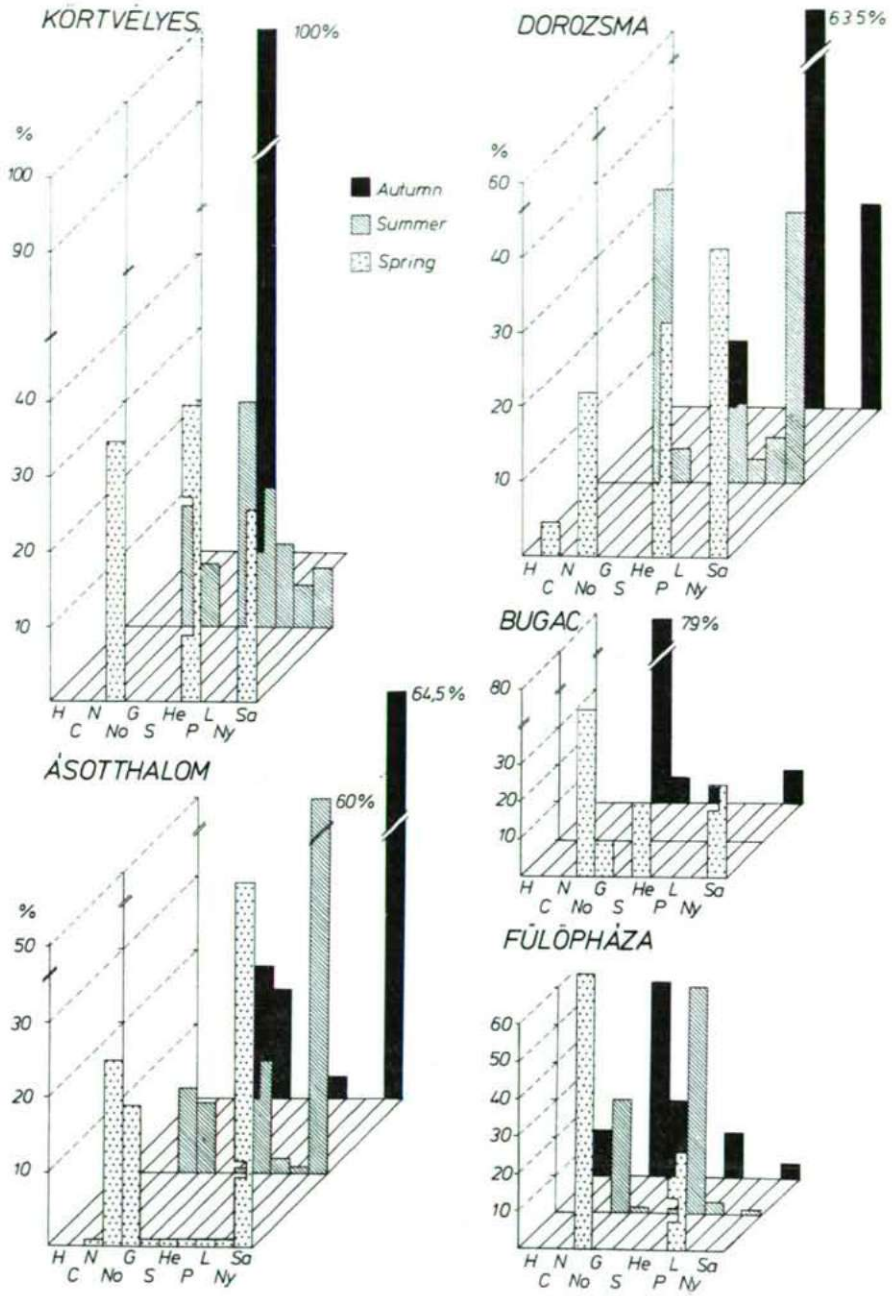


Fig. 2. Quantitative distribution of Lepidoptera families according to time periods. H = Hepialidae, C = Cossidae, N = Notodontidae, No = Noctuidae, G = Geometridae, S = Sphingidae, He = Hesperidae, P = Pieridae, L = Lycaenidae, Ny = Nymphalidae, Sa = Satyridae.

areas, but in sandy sites (Ásotthalom, Fülöpháza) Renkonen's index is lower in spring and summer relation. So in the latter case the importance of the populations characterising the spring aspect (and not in common) is higher than in other areas. The aspect divergence is least in the fauna of sodic area.

Comparing the different areas' annual relations (Table 3) Renkonen's index is almost twice as high as species similarity in the three most important areas, so the common species have a considerable proportion everywhere. According to present investigations the biotop specificity of Macrolepidoptera species is relatively low. In seasonal relation (Table 4) this specificity is the least in spring. The 42 p.c. similarity between inundation and sodic areas is apperent. The differences are highest in autumn.

Cicadinea

Investigating in the quantitative distribution of Cicadinea families (Table 5) Cicadellidae is dominant everywhere and in some areas Delphacidae is subdominant. Cercopidae is important in spring and autumn and the higher ratio of Cixiidae at Dorozsma can also be mentioned.

Table 5. Quantitative distribution of Cicadinea families

Familia %	Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac	
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au
1. Achilidae	—	—	—	—	—	—	0.78	0.91	—	—	—	—	—	
2. Cercopidae	1.15	0.62	3.33	2.94	0.80	12.50	9.37	0.45	1.92	6.66	5.88	—	0.51	11.11
3. Cicadellidae	98.46	95.00	93.33	70.58	80.64	75.00	32.81	90.36	92.30	93.33	76.47	16.66	97.61	66.66
4. Cixiidae	—	1.25	3.33	11.76	13.70	—	0.78	—	—	—	11.76	—	—	—
5. Delphacidae	0.38	3.12	—	11.76	4.83	12.50	48.43	8.25	5.76	—	5.88	83.33	1.87	22.22
6. Dictyophoridae	—	—	—	2.94	—	—	—	—	—	—	—	—	—	—
Sum total: %	100	100	100	100	100	100	100	100	100	100	100	1 00	100	100

Renkonen's indices of the different aspects within an area are higher than Jaccard's indices almost everywhere (Table 6) except the inundation area. So, in the latter case the spring and summer populations are different while the majority of autumn species occurs already in summer.

The result of the comparison between different areas' annual relations are shown in Table 7. The habitat specificity of Cicadinea group is shown by the fact that the majority of Renkonen's indices is much less than the corresponding Jaccard's indices. This means that the majority of populations of high dominancy is habitat specialist. There are only two exceptions' Ásotthalom—Fülöpháza and Fülöpháza—Dorozsma sodic area relations where the relatively high number of common sandy and sodic species increased the degree of similarity. On this basis comparing qualitative and quantitative relations the inundation and sodic areas have the most specific Cicadinea communities. The other areas have also high fauna specificity except sandy areas of Fülöpháza.

Table 6. Values of Renkonen's indices of Cicadinea according to time periods in annual relations

	Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac	
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au
Sp	100	9.97	12.92	100	34.24	20.58	100	32.22	19.69	100	17.64	0.00	100	1.70
Su		100	72.70		100	14.49		100	17.64		100	0.00		
Au			100			100			100			100		100

Table 7. Values of Renkonen's indices of Cicadinea species according to areas in annual relations

Table 8. Values of Renkonen's indices of Coleoptera species according to areas in annual relations

Table 7

K	D	Á	F	B	
100	11.61	3.15	8.16	2.81	K
	100	7.77	37.29	3.27	D
		100	21.42	3.57	Á
			100	3.00	F
				100	B

Table 8

K	D	Á	F	B	
100	42.47	15.40	25.00	14.62	K
	100	17.72	34.85	17.18	D
		100	39.63	18.85	Á
			100	19.24	F
				100	B

Coleoptera

Coccinellidae is the only family that is dominant in all habitats. It is important in summer in the flood area, in all aspects in sodic and sandy areas, in the sandy area at Fülöpháza in summer and autumn and at Bugac in autumn (Fig. 3).

Curculionidae, Melolonthidae and Chrysomelidae are characteristic of three areas each in considerable proportion. Curculionidae is predominant in autumn Melolonthidae and Chrysomelidae in spring.

Carabidae and Cantharidae are predominant in two habitats. Cantharidae is characteristic of the spring period of the flood and sodic areas and Carabidae is typical in autumn at Bugac and in the flood area.

Five families were restricted to only one habitat: Alleculidae and Oedomeridae to sandy areas in spring and summer, Elateridae to flood area in spring and summer, Mordellidae and Lagriidae to Fülöpháza in spring and summer.

Differences between Renkonen's and Jaccard's indices can already be seen in annual relations (Table 8). Renkonen's index shows greater differences between areas. On the basis of Jaccard's index the degree of similarity is twice as high as in the case of Renkonen's index, so besides Macrolepidoptera, Coleoptera seems to be the second group with least habitat specificity.

It is also shown by the detailed data of aspects (Table 9) that the Coleoptera fauna of sandy areas differs from that of inundation and sodic areas in quantitative relations, but their similarity increased in summer by 5 p.c. The autumn differences increased. The similarity of Coleoptera fauna of sodic areas being quantitatively most

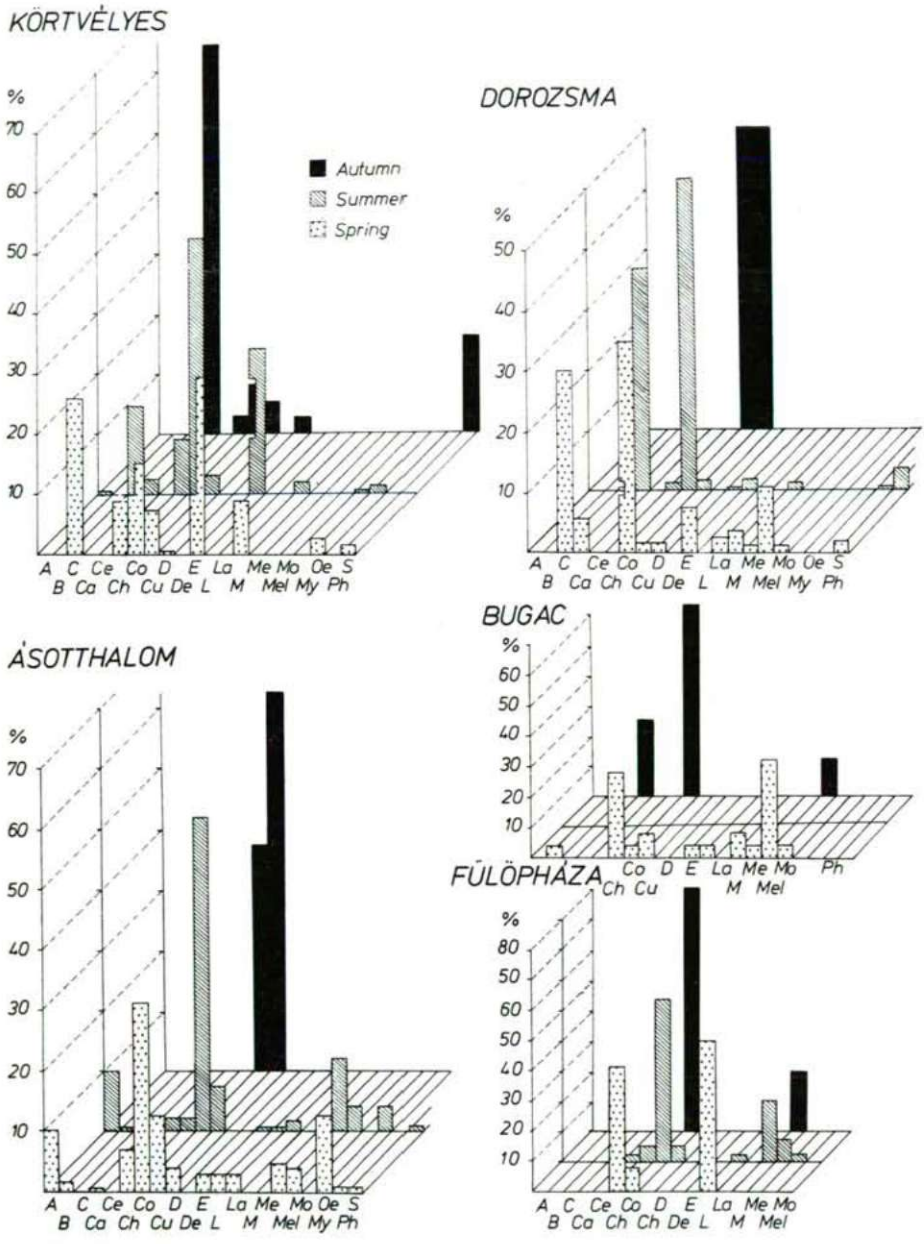


Fig. 3. Quantitative distribution of Coleoptera families according to aspects. A = Alleculidae, B = Buprestidae, C = Cantharidae, Ca = Carabidae, Ce = Cerambycidae, Ch = Chrysomelidae, Co = Coccinellidae, Cu = Curculionidae, D = Dasytidae, De = Dermestidae, E = Elateridae, L = Lagriidae, La = Lampyridae, M = Malachidae, Me = Meloidae, Mel = Melolothidae, Mo = Mordellidae, My = Mylabridae, Oe = Oedemeridae, Ph = Phalacriidae, S = Staphylinidae.

Table 9. Values of Renkonen's index of Coleoptera species

Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac			
Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au		
100	54.73	8.83	30.54			7.12			0.68			4.67		Sp	
	100	9.36		31.62			19.09			36.77				Su	K
		100			8.10			5.40			8.10		0.00	Au	
			100	27.41	6.45	10.32			4.03			10.48		Sp	
				100	23.31		16.04			39.13				Su	D
					100			25.00			45.00		25.00	Au	
						100	53.59	2.36	7.08			10.23		Sp	
							100	6.61		25.93				Su	Á
								100			32.50		25.00	Au	
									100	16.01	8.33	12.33		Sp	
										100	35.90			Su	F
											100		20.00	Au	
												100	4.00	Sp	
														Su	B
													100	Au	

differentiated increased in spring and summer to a great extent. The spring Coleoptera aspect of the inundations area which is the other very differentiated area, approximated sodic areas owing to the high dominance ratio of family Cantharidae. Its summer composition neared the other areas' but it definitely receded in autumn.

Diversity

The index of diversity is the resultant of two components. It depends both on the species richness of the taxonomic group investigated and on the eveness of distribution (PIELOU, 1969). The greater the index of diversity is the richer the species composition is or the more evenly the dominancies are distributed. These two factors are not random.

There are relations between floral and faunal diversities. In the case of plants both taxonomic and spatial diversity i.e. spatial distribution of floral structures are equally important (SOUTHWOOD, BROWN and READER, 1979). In the early period of succession the diversity of insects rather depends on taxonomic diversity and the importance of structural diversity increases near climax (LAWTON, 1978). The species richness of herbivor insects depends on the geographical distribution of plant species too. Comparing plant species of similar geographical areas the following sequence can be noticed in the richness of their insect fauna: trees > woody shrubs > perennial herbs > weeds and other annuals > monocots (LAWTON and SCHRÖDER, 1978). So the struture of plants is also very important as larger and more complex plants ensure more niches (LAWTON, 1978). There are also seasonal changes in diversity. It is caused by the changes in chemical properties of plant (chemical hypothesis) and by architectural changes of plant (architecture hypothesis, LAWTON, 1978).

On this basis questions can arise whether the investigated insect groups of a more complex habitat are more divers and whether the material of Malaise trap is sufficient

to express this. The species diversity of insect groups investigated can be seen in Table 10.

First analysing Lepidoptera and Cicadinea groups including phytophagous populations it can be established that order Lepidoptera fits LAWTON's arrengement, its diversity is the highest in woody areas and less in grasslands, but Cicadinea has greatest diversity in sodic and sandy grasslands and it is least in the woody flood area. The species richness of Macrolepidoptera is similar, that of Cicadinea shows a less eveness in forests than in grasslands.

There are not essential differences between areas in the diversity of Coleoptera, it is a little higher in woody areas. Their species richness is almost the same as well. Perhaps figures would change if we separately studied the trophic groups because plant eaters, predators and decomposers are together in this analysis.

The diversity of Hymenoptera is conspicuously higher than that of the other groups. It is caused by the high number of species without doubt. This is almost iden-

Table 10. Diversity of important insect groups (whole year)

	Ásotthalom	Dorozsma	Körtvélyes	Fülöpháza	Bugac
Hymenoptera	5.2343	4.7974	5.2558	3.4593	4.5851
Lepidoptera	3.0210	2.5864	3.0593	2.8030	2.6818
Cicadinea	2.1365	2.7344	1.8023	2.6722	0.5578
Coleoptera	2.9712	2.7477	2.905	2.7078	2.8027

tical in sandy and flood area woods but in the sodic grassland it is less than the half of it. The difference in the diversity index is less because the eveness is greater in the sodic grassland area.

It is also interesting to compare the diversity indices and species richness between taxonomic groups of insects and between areas (Table 11, Fig. 4).

The diversity dynamics of Macrolepidoptera follows the dynamics of species number rather well only in the inundation area (Fig. 4/a). The faunal eveness is the highest here in summer in sodic and sandy areas in spring. The number of Cicadinea

Table 11. Seasonal values of species diversity of important insect groups

	Ásotthalom			Dorozsma			Körtvélyes		
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au
Hymenoptera	4.9268	4.5501	3.7064	4.0165	4.2660	2.5003	4.6769	4.5260	3.8757
Lepidoptera	2.8202	2.4528	1.7658	2.1818	2.2001	1.1595	2.4998	2.9315	0.00
Cicadinea	2.1814	1.2334	2.1247	2.2457	2.4282	1.6674	1.1270	1.4801	1.4352
Coleoptera	2.7796	2.5852	0.9002	2.6050	2.8982	1.0397	2.4875	2.5086	1.8538

	Fülöpháza			Bugac	
	Sp	Su	Au	Sp	Au
Hymenoptera	1.3862	3.3814	1.5402	4.5424	2.4807
Lepidoptera	1.8343	1.8524	2.8997	2.1738	2.0211
Cicadinea	2.0782	1.9250	0.4505	0.4780	1.6769
Coleoptera	1.3577	2.6249	1.3321	2.5461	2.3630

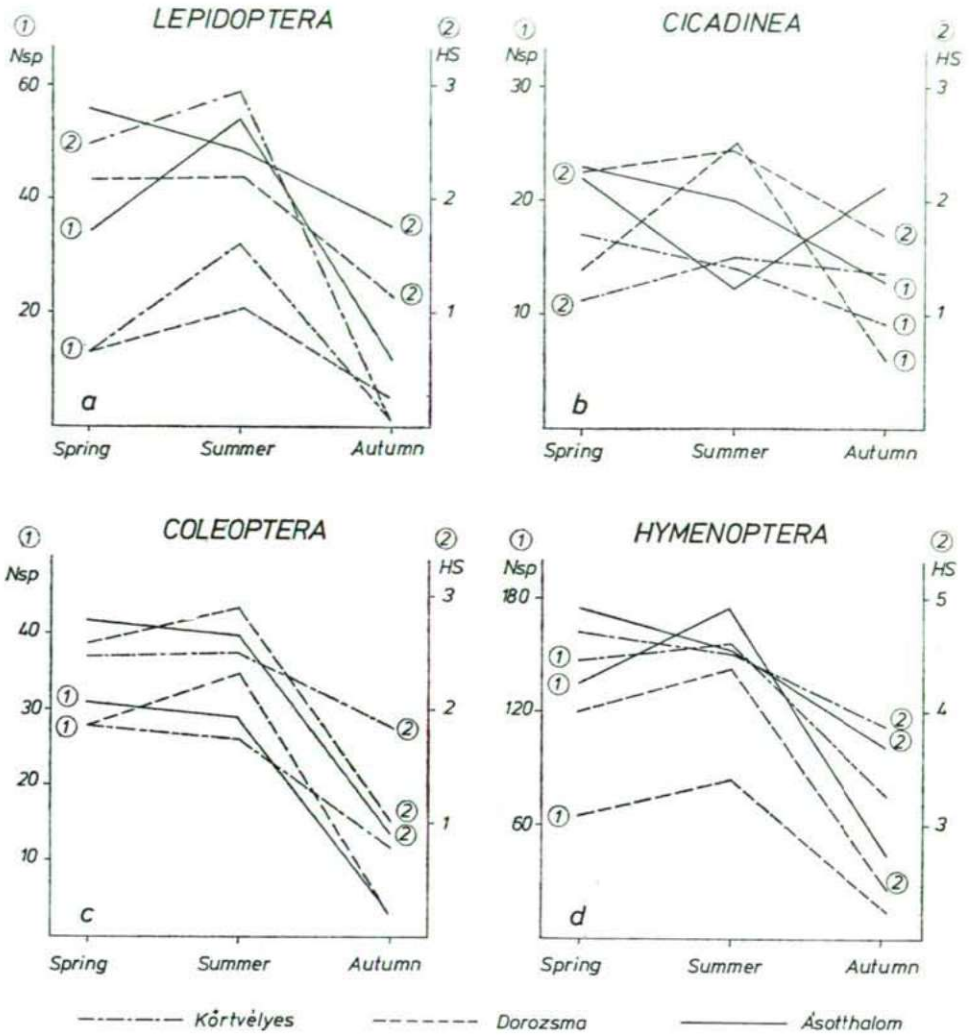


Fig. 4. Seasonal dynamics of species number and species diversity.

species — that are also herbivor groups — is very similar to that of Lepidoptera larvae studied by FEENY (1970). So it is highest in spring and decreases to autumn in woody areas, but a summer maximum was found in sodic areas (Fig. 4/b). Comparing it with dynamics of diversity it is shown that the eveness component changes this situation at Ásotthalom and Körtvélyes. The eveness is very low in sandy areas in summer and in the inundation area in spring which causes a decrease in diversity indices. The changes in the number of Coleoptera species is similar to those of Cicadinea and it is followed by the diversity, so the eveness is almost the same in the single areas. The population eveness of Hymenoptera having highest diversity and species number is

similar in inundation and sodic areas, there is no significant difference between the curves of richness and eveness. Although there is a summer maximum in species number in sandy areas, the highest diversity was measured in spring, so the fauna eveness in spring is much higher than in other areas (Fig. 4/d).

References

CHANTER, D. O. (1965): The Malaise trap. — Entomol. Rec. *77*, 224—226.

FEENY P. (1970): Seasonal changes in oak leaf tannins and nutrients as a cause of spring feeding by winter moth caterpillars. — Ecology *51*, 565—581.

GEIJKES, D. C. (1968): Insect collecting in Suriname with the help of "Malaise" traps. In: Studies on the fauna of Suriname and other Guyanas, no. 39. — Natuurwetensch. Studierkring Suriname Ned Antillen *48*, 101—109.

LAWTON, J. H. (1978): Host-plant influences on insect diversity: the effects of space and time. In: Mound, L. A. and Waloff, N. (eds.), Diversity of insect faunas. — Symp. of Royal Entomol. Soc. London *9*, 105—125.

LAWTON, J. H. and SCHRÖDER, D. (1978): Some observations on the structure of phytophagous insect communities: the implications for biological control. — Proc. 4th Int. Symp. Biol. Control Weeds, Gainesville, Florida, 57—73.

MALAISE, R. (1937): A new insect trap. — Entomol. Tidskrift *58*, 148—160.

MARSTON, N. (1965): Recent modification in the design of Malaise traps with a summary of the insects represented in collections. — J. Kansas Entomol. Soc. *38*, 154—162.

MATTHEWS, R. W. and MATTHEWS, J. R. (1970): Malaise trap studies of flying insects in a New York mesic Forest. I. Ordinal composition and seasonal abundance. — J. N. Y. Entomol. Soc. *78*, 52—59.

MATTHEWS, R. W. and MATTHEWS, J. R. (1971): The Malaise trap: its utility and potential for sampling insect populations. — The Michigan Entomol. *4*, 117—122.

MÓCZÁR, L. (1967): Trap automatic for capture of flying insects. — Folia Entomol. Hung. *20*, 213—221.

MÓCZÁR, L. and GYÖRFFY, GY. (1981): Malaise trap investigations in inundation, sodic and sandy areas I. Quantitative relations. — Acta Biol. Szeged. *27* (1—4), 169—179

PIELOU, E. C. (1969): Introduction to mathematical Ecology, New York: Wiley.

SOUTHWOOD, T. R. E., BROWN, V. K. and READER, P. M. (1979): The relationships of plant and insect diversities in succession. — Biol. J. Linn. Soc. 327—348.

Address of the authors:
Dr. GY. GYÖRFFY
Prof. Dr. L. MÓCZÁR
Department of Zoology, A. J. University
H-6701 Szeged P. O. Box 428. Hungary

Acta Biologica Szeged. 27 (1—4), pp. 195—201 (1981)

MORPHOLOGICAL STUDIES ON THE LARVAL HINDGUT OF SOME ANISOPTERA SPECIES

KATALIN HALASY and MÁRIA CSOKNYA

Department of Zoology, Attila József University, Szeged

(Received September 20, 1980)

Abstract

The respiratory organ of the larvae of Anisoptera is the so called rectal tracheal gill wich can be found in the modified rectum. According to the form and arrangement of the gills the investigated species belong to the third group of Tillyard-division. The lamelliform gills are covered by respiratory epithel. The epithelial cells are poor in organelles, they are distributed by invaginations of basal membran. Tracheoles are visible among the invaginations. The chitin-spinules of the anal papilla remove the mechanical dirt from the respiratory water. The spinules are simple or bifurcated.

We investigated the next species: *Aeschna cyanea* (MÜLL.); *Aeschna affinis* (VANDERL.); *Libellula quadrimaculata* (L.); *Leucorrhinia pectoralis* (CHARP.).

Introduction

As it is well-known the digestive system of insects consists of 3 parts namely: foregut midgut and hindgut. Foregut and hindgut is generally covered by thin cuticle. The main function of the foregut is storage, that of the midgut is digestion and absorption and that of the hindgut is mainly the passing of indigestible materials and decomposed from the malpighian tubules substances (GRASSÉ et al., 1949; WESENBERG-LUND, 1943). In addition — especially in the last part of the hindgut — absorptive processes take place as well. So the hindgut is an important place of excretory and osmoregulatory functions too (BERRIDGE, 1969; GRASSÉ et al., 1949; JUDD, 1948; KOVOOR, 1971; WESENBERG-LUND, 1943).

In case of some Insecta species the parts of the digestive system can remarkably modify, and they can fulfill other functions beside the above mentioned. So the hindgut of the larvae of Anisoptera (Odonata) takes part in the respiration as well.

Our aim was to study the respiratory chamber, respectively the rectal tracheal gills of some Anisoptera larvae.

Materials and Methods

We investigated into the larvae of the next Anisoptera species:

Aeschna cyanea (MÜLL.)	(Aeschnidae)
Aeschna affinis (VANDERL.)	(Aeschnidae)
Libellula quadrimaculata (L.)	(Libellulidae)
Leucorrhinia pectoralis (CHARP.)	(Libellulidae)

The determination was carried out by the taxonomic keys of STEINMANN (1964) and ÚJHELYI (1957). We used animals fixed in 10% formaldehyde as well as freshly collected animals. Paraffin sections (5—7 μ) were made from the materials fixed in Bouin and 10% formaldehyde that were stained with haematein-eosin, by van Gieson and Mallory (KISZELY et al., 1958).

Material fixed in 10% formaldehyde resp. 2,5% glutaraldehyde was used for the scanning electronmicroscopy. The secondary fixation was carried out in 2,5% $KMnO_4$. The specimens were studied by EM-ASID-I scanning apparatus of JEOL-100-B electronmicroscope.*

Results and discussion

The hindgut of Anisoptera-larvae — like that of other Insects — consists of 2 parts: ileum (or colon) and rectum. These 2 parts are different in their appearance as well. The ileum comes into sight next to the junction of malpighian tubules. This hollow is globular in the species Aeschna (Table 1, Fig. 1), oval in Libellula, and annular at Leucorrhinia (Table 1, Fig. 3).

Rectum is the most various anatomically as well as functionally. It has 3 parts. Its first part is the very short proper rectum with regular intestine structure. Its internal surface is gently plicate (Table 1, Fig 3) (BERRIDGE, 1969). Its middle part expands and smaller tracheas are gathered from its wall into the dorsal and ventral visceral trunks of tracheas on the both side of the intestine (Table 1, Fig. 1). This part of the rectum is the so called respiratory chamber (MILL, 1970; MILL et al., 1972; WESENBERG-LUND, 1943). The gills can be found on its internal surface (Table 1, Fig. 2, 3, 4, Table 2, Fig. 1). The third that is last part is the so called atrium or vestibulare. There are no gills in it (Table 1, Fig. 2, 3, 4). Atrium is closed by the anal valve (SHARP, 1901; TILLYARD, 1917).

At the end of the abdomen there are 5 so called anal pyramids (STEINMANN, 1964; ÚJHELYI, 1957). A narrow canal is formed by the wider concave turned towards each other sides of pyramids in wich the respiratory water can flow in and out. Chitinous spinules are visible on the sides of of the pyramids, that are longer on the inner sides. They can be simple filiform (0,37 mm long), (Table 3, Fig. 1) or bifurcated (0,28 mm long) proturberances (Table 3, Fig. 2). Their role is presumably the mechanical cleaning of respiratory water.

The wall of the respiratory chamber is thin its musculature is slightly developed. This is explained by Mill and his colleagues (1970; 1971; 1972); they demonstrated experimentally that the circulation of respiratory water is carried out by certain muscles of the abdomen.

The protuberances of the inner wall of respiratory chamber are the gills wich are lamelliform in the case of the investigated species. Differences are to be found only in the shape of the lamellae: the gills of Aeschna-species are roundish (Table 1, Fig. 3), that of Leucorrhinia are elongated leaf-like (Table 1. Fig. 4), and that of Libellula are ovale (Table 2, Fig. 1, 2). The lamellae are arranged in double lines like rooftiles

* We wish to thank Dr. NORBERT HALÁSZ for his help in the use of scanning electronmicroscope.

Table 1

Fig. 1. detail of the intestine of *Aeschna affinis* (VANDERL.) 40x
Fig. 2. opened respiratory chamber of *Aeschna affinis* (VANDERL.) 40x
Fig. 3. enlarged picture of rectal tracheal gills of *Aeschna affinis* (VANDERL.) 80x
Fig. 4. opened respiratory chamber of *Leucorrhinia pectoralis* (CHARP.) 40x

Table I

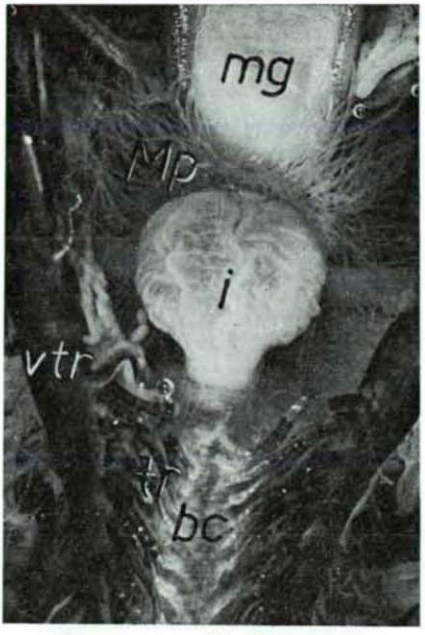


Fig. 1.

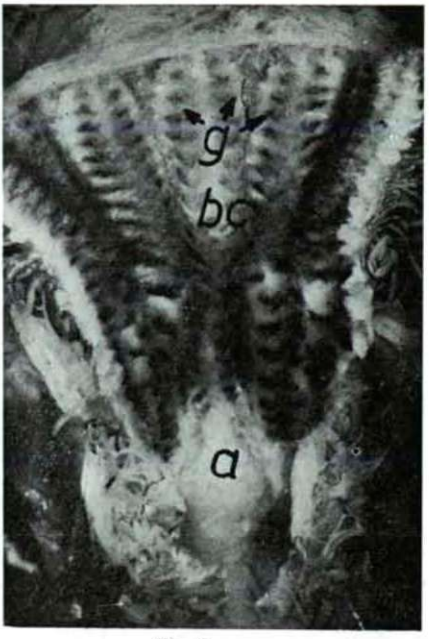


Fig. 2.

Fig. 3.

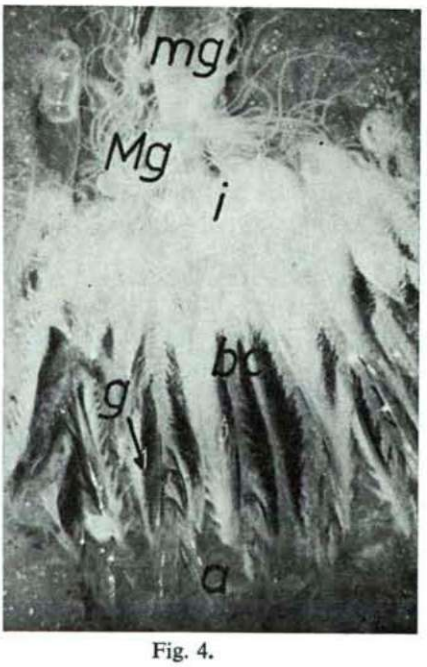


Fig. 4.

Table II

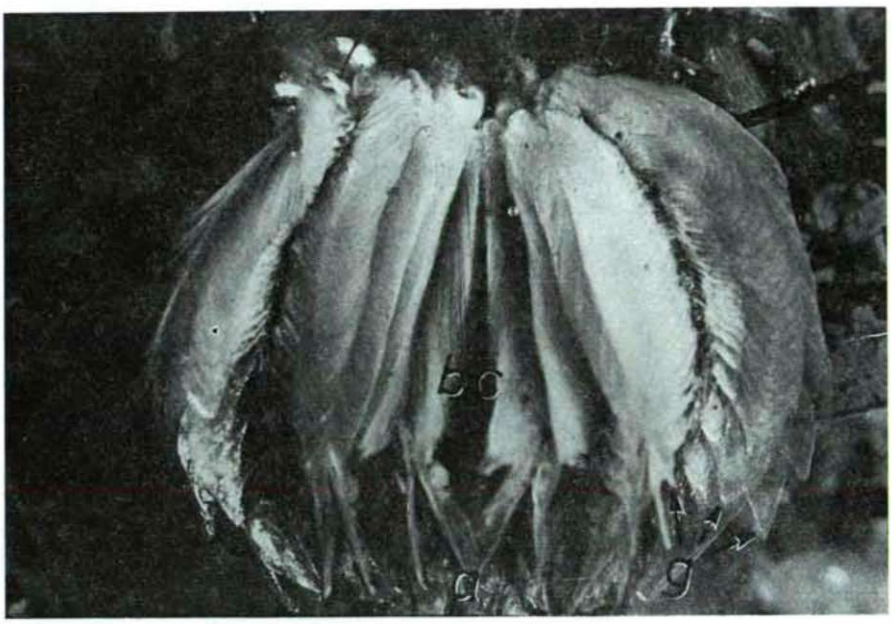


Fig. 1

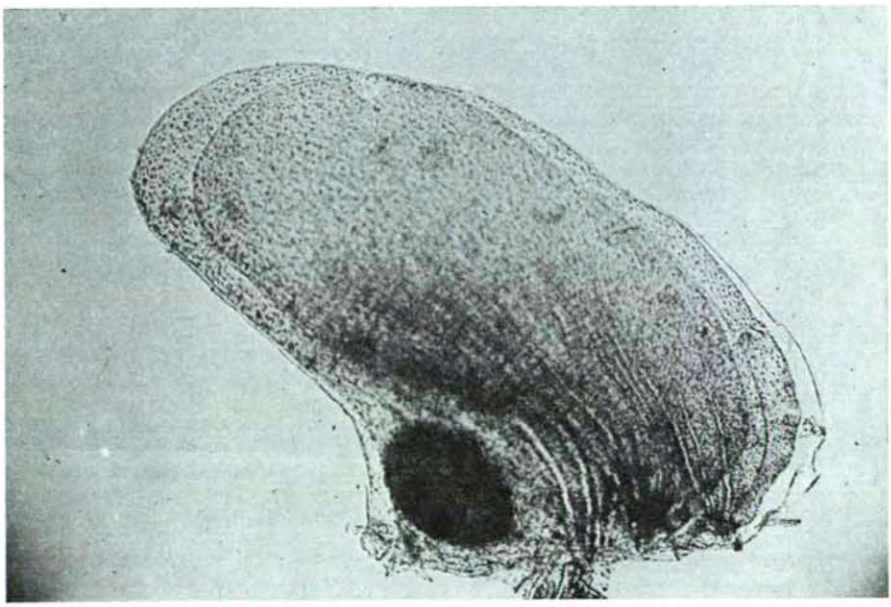


Fig. 2

Fig. 1. respiratory chamber of *Libellula quadrimaculata* (L.) 80x
Fig. 2. dissected gill-lamella of *Libellula quadrimaculata* (L.) 120x

Table III

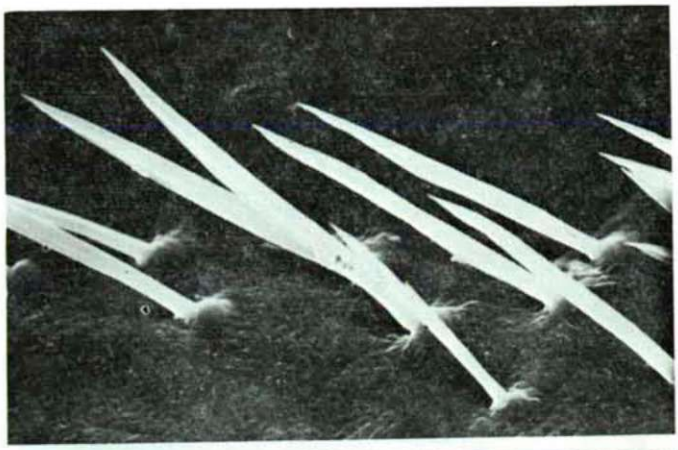


Fig. 1

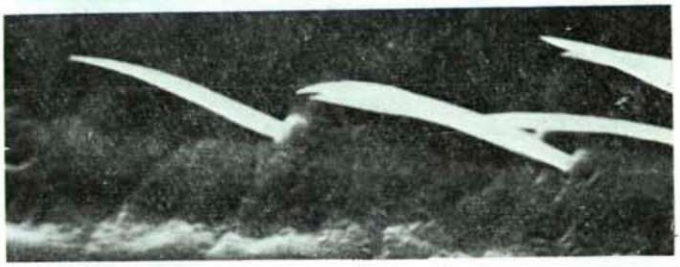


Fig 2

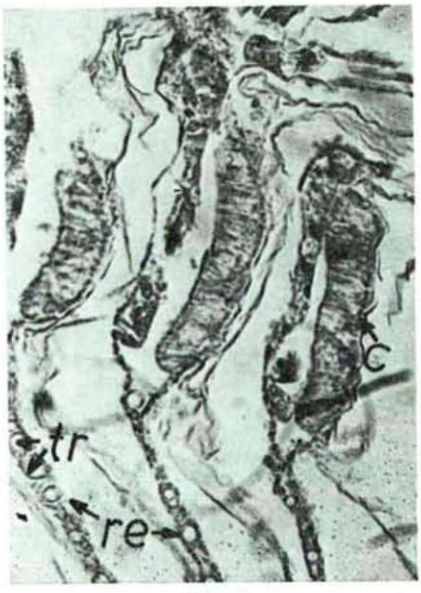


Fig. 3

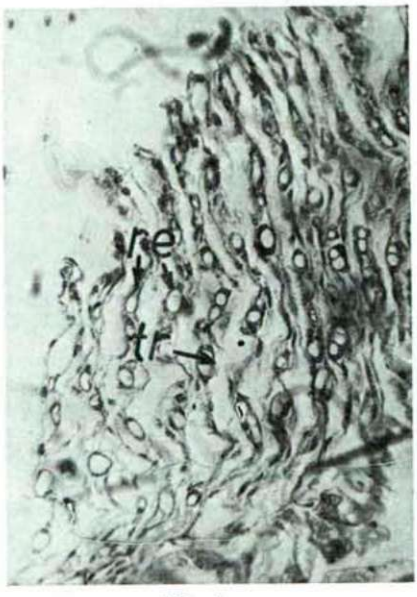


Fig. 4

Fig. 1. 2. scanning picture of anal pyramids of *Aeschna cyanea* (MÜLL.) 120x
Fig. 3. cross-section of respiratory chamber of *Libellula quadrimaculata* (L.) heamatein-eosin staining 400x
Fig. 4. cross-section of rectal tracheal gills of *Leucorrhinia pectoralis* (CHARP.) haematein-eosin staining 400x

a = atrium
bc = respiratory chamber
c = cuticle
g = gill
i = ileum
mg = midgut
Mp = malpighian tubules
re = respiratory epithel
tr = trachea-branches
vtr = visceral trachea-trunk

and they form 8 lines in the respiratory chamber. Their number is about 20 000—24 000 (SHARP, 1901). According to the form of lamellae and the junction of their trachea-branches into the visceral trunk the investigated species belong to the third group of TILLYARD (1917) — division of intestine gills. This type provides very large respiratory surface.

The specimens from the respiratory chamber unanimously confirm that only epithel of the intestine takes part in the formation of the lamellae. On the base of the lamellae the epithel cells are cylindric or cubic (Table 3, Fig. 3, 4) wich on the area of the lamellae suddenly flatten out. The basic cells stain deeply, in their cytoplasma basophil granules are visible.

The flat epithal cells of the lamellae are poor in organelles (WICHARD, 1979) and are covered by thin cuticle. Among the cells and among the basal invaginations of the cells tracheoles are visible. These tracheoles are of different diametres and their position is irregular. This arrangement ensures probably the most complete respiration.

In the epithel cells of rectal tracheal gills pigment granules can be seen as well. The quantity of these differs according to species so in Libellula quadrimaculata is very few in Leucorrhinia pectoralis little pigment granules can be found along the dorsal margin of the lamellae wich appears already at dissection like a dense stripe (Table 1, Fig. 4).

The rectal tracheal gills of the investigated larvae of Anisoptera are very similar structurally. Their position and supply with tracheas ensures the optimal respiration.

Literature

BERRIDGE, M. (1969): A structural analysis of intestinal absorption. — In A. C. NEVILLE: Insect Ultrastructure. — Symp. Roy. Ent. Oxford, Edinburg 135—151.
GRASSÉ, P. P. (1949): Traité de zoologie — Insectes. IX. — Masson et Co.
JUDD, W. W. (1948): A comparative study of the proventriculus of orthopteroid insects with reference to its use in taxonomy. — Can. J. Res. *26*, 93—161.
KISZELY GY. és BARKA T. (1958): Gyakorlati mikrotechnika és hisztokémia. — Medicina, Budapest.
KOVOOR, J. (1971): Anatomie comparee du tube dígestif des Termites. III. Sous-famille de Macrotermitinae. — Insectes Sociaux *18*, 49—70.
MILL, P. J. (1970): Neural patterns associated with ventilatory movements in dragonfly larvae. — J. Exp. Biol. *52*, 167—175.
MILL, P. J. and LOWE, D. A. (1971): Ultrastructure of the respiratory and non-respiratory dorsoventral muscles of the larva of a dragonfly. — J. Insect Physiol. *17*, 1947—1960.
MILL, P. J. and PICKARD, R. S. (1972): A review of the types of ventilation and their neuronal control in Aeschnid larvae. — Odonatologica *1*, 41—50.

SHARP, D. (1901): The Cambridge natural history (Insecta I.) — Macmillan and Co. London, New York.
STEINMANN, H. (1964): Insecta I. — Larvae Odonatorum. — Fauna Hung. 69 (V.) 7. füzet.
TILLYARD R. J. (1917): The biology of dragonflies. — Cambridge Univ. Press, Cambridge.
ÚJHELYI, S. (1957): Insecta I. — Odonata. — Fauna Hung. *18*, (V.) 6.
WESENBERG-LUND, G. (1943): Biologie der Süsswasserinsekten. — Nordisk Forlag, Kopenhagen und Verlag — J. Springer Berlin, Wien.
WICHARD, W. (1979): Zur Feinstruktur der abdominalen Tracheenkiemen von Larven der Kleinlibellen — Art Epallage fatime (Odonata: Zygoptera: Euphaeidae). — Ent. Gen. *5*, 129—134.
WICHARD, W. and KOMNICK, H. (1974): Zur Feinstruktur der rektalen Tracheenkiemen von Anisopteren Libellenlarven. II. Das rektale Chloridepithel. — Odonatologica *3*, 129—135.

Address of the authors:
Dr. KATALIN HALASY
Dr. MÁRIA CSOKNYA
Department of Zoology, A. J. University,
H-6701 Szeged, P. O. Box 428. Hungary

Acta Biologica Szeged. 27 (1—4), pp. 203—208 (1981)

INVESTIGATIONS ON THE PRODUCTIVITY OF THE MACRODECOMPOSER ISOPOD, TRACHELIPUS NODULOSUS C. L. KOCH

ERZSÉBET H. HORNUNG

Department of Zoology, Attila József University, Szegea
(Received September 15, 1980)

Abstract

The productivity parameters of macrodecomposer Arthropods were investigated on the laboratory populations of the Isopod Trachelipus nodulosus, mainly by laboratory methods. By the measurements the daily food consumption of the adult individuals (C) is 1,57% of their body weight the daily growth of their biomass is 0,25%. The increase of biomass from components of the production gives a logistic curve as a function of age.

The calorific content of animal body, food and faeces was determined by a Phillipson microbomb calorimeter. The values agree with the data given in the literature for other species.

Introduction

The Isopods were investigated because of their role in decomposition in the earlier years, too (DUDICH et al., 1952; GERE, 1956a, 1956b, 1962; MCBRAYER et al, 1971; PARIS et al., 1967; WHITE, 1968). The authors of publications written about the material and energy turnover of these populations made their studies in forests of different types (REICHLE, 1967; SAITO, 1965, 1969; STACHURSKY, 1972, 1974). Little is known about the Isopods' ecological position and role in grasslands (PARIS et al., 1962; PARIS et al., 1965; WIEGERT et al., 1967). No Hungarian investigation is known in this theme. The aim of this work is to examine the productivity of an Isopod species widely distributed in the grassland of the Hungarian Plain.

Materials and Methods

The animals used for measurements were originated from the "Emlékerdő" at Ásotthalom, in the neighbourhood of Szeged and from the area Bugacpuszta in the Kiskunság National Park (Hunary).

The investigated parameters:

the total food intake (C),
the production (P),
the respiration,
the rejecta (FU), that part of total food intake wich is not used for production and respiration.

The single parameters were named on the basis of the nomenclature of PETRUSEWICZ (1976a, 1976b), and PETRUSEWICZ and MACFADYEN (1970). The measurements concerning the respiration of the species are discussed in a separate paper, so they are not detailed now.

For determing the food consumption of juvenil and adult animals separate measurings were carried out. As the Isopods are very sensible for the humidity of their surroundings and the change of water content of their food respectively, assuring the suitable circumstances requires much care. For preventing the desiccation of the animals, the experimental populations were kept in glass dishes. On the bottom of the dishes filterpapers cut to size were placed, with their daily re-moistening I insured the required moisture degree of food and air. 100—100 juvenil animals were placed in the dishes in the parallel experiments, inmediately on the day after their hatching. (The individuals were hatched already in the laboratory by pregnant femails collected previously.)

Dead plant material (*Populus alba* leaf-litter) originated from the locality place of the animals was used as food. It was dried (60 °C, 2 days) and the dry weight of every portion given to the animals was weighted. The dry plant material was rehydrated one day long before using. Control measurements were made in every case when plant material—treated in the same way—was placed in dishes without animals, so it was possible to determine the oxidative weight-loss and to make corrections. As on the damp plants mold appears after about 5 days, it seems practical to exchange the plants for new ones. This is confirmed by WHITE's observations (1968). The change in the animals' number was recorded, their living weight was observed and the faeces was removed after every ten days. The remained plant material and feaces were weighted after drying (60 °C, 2 days). During the experiments the environmental temperature was 20 °C. There was no possibility to remove the dead individuals and the exuviae because they were aeten by the animals presumably for supplying their high Ca-demand. So called model-populations — consisting 5—5 individuals — were used for determining the food consumption of adult animals. It was carried out under the same circumstances as before. These measurements were continued 10—10 days, the total biomass, then it's dry weight, the food and food remains, the faeces were weighted — in dry weight — at the beginning and after finishing the experiments. The values measured in laboratory give only informatory data, the examined parameters are influenced by more factors, their volume changes under natural circumstances. The calory contents of animal body, food, faeces were determined by Phillipson microbomb oxygen calorimeter. Pills — with the weight of 4—30 mg — were made by pressing from the examined materials, after drying and pulverizing. The samples known in weight were burned in oxygen gas, at 30 atm pressure. After burning the animal body relatively large quantity of ash remained, owing to the high Ca-content, and the data were corrected with its weight. The heat amount resulted by the burning could be read off with intercession of a thermo element on a Honeywell potentiometer. The calibration of the calorimeter was made with benzoic acid.

Results and discussion

Food consumption: Figures 1. and 2. show the food consumption, the cumulative values of FU and A for juvenil laboratory populations in mg/mg animal per day. The initial time means the one day old individuals. Comparing the two figures it is evident that in the case of different initial individual number over and above the prominent irregular mortality, the amount of C, FU and A relating the same time period is also different. (In the same way fundamental differences are concerning the weight growth of the two populations being in dishes with the same surface and supplied with sufficient food.) It appears from the curves that the food consumption of a body weight unit is slowing down in time. That of juveniles is relative higher (Fig. 3). In the case of adult individuals the daily food consumption is 1,57 per cent, the daily growth of their biomass is 0,25 per cent of their body weight.

Assimilation efficiency: the relation of the assimilated material (A) to the food ingested is generally used for the characterisation of the amount of assimilated material. This assimilation efficiency (A/C) was examined in Isopods by different authors. The values given by them are very different, but it turns out unambigously that assimilation efficiency under laboratory circumstances is generally low, it's value remains between 6—53 per cent on the basis of the data detailed in Table 1. Under field circumstances these values are much higher, 53—75 per cent as it turns out from the

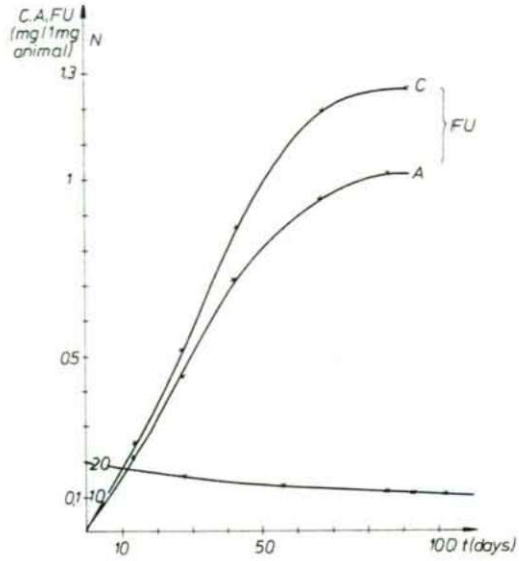


Fig. 1

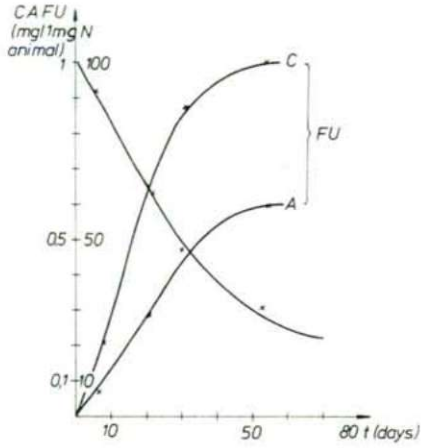


Fig. 2

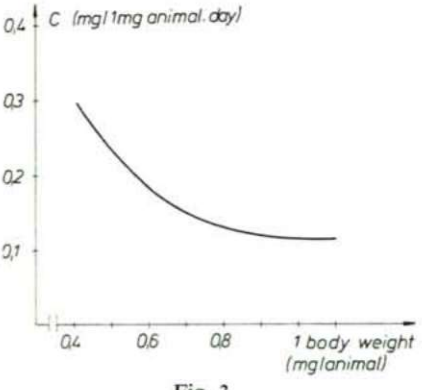


Fig. 3

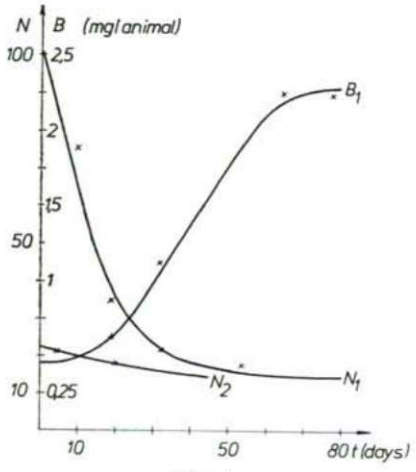


Fig. 4

Fig. 1—2. C, A and FU values of juvenil model populations (mg/lmg animal, 1 day), at different initial individual numbers.

Fig. 3. The food consumption per body weight unit decreases with the growth of body weight.

Change of indi vidual number of model populations in time (N_1) respectively the logistic curve of biomass (B_1) changes; mortality at low initial number of individuals (N_2).

measurements of HUBBEL et al. (1965) and REICHLE (1967) who made them with isotop technics. WHITE (1968) proved that the assimilation efficiency is decreasing when the food passes through the intestines rapidly. Under natural circumstances these animals look for sites with lower temperature, where their metabolism is slower and much more effective. The A/C rate depends on the body size of the animals and on the quality of food, too. Among others these can explain the very diverse results of the different authors. In my own investigations the assimilation efficiency of *Tr. nodulosus* was found to be 46,78 per cent. This shows a very good congruence with the ascertainment of SAITO and STACHURSKY who assumed the A/C rate to be 50 per cent.

Table 1	A/C rate (%)	°C	author
Glomeris sp.	10,9—22 23	—	BOCOCK, 1963
Armadillidium vulgare	29—53	20	SAITO, 1969
	64	20	REICHLE, 1967
A. vulgare in laboratory	6—13	23	HUBBEL et
outdoor	53—75	10	al 1965
Oniscus asellus	16.2	20	HARTENSTEIN, 1964
Protracheoniscus politus	16.7	20	GERE, 1956
Cylisticus convexus	60	20	REICHLE, 1967
Ligidium hypnorum	50	—	STACHURSKY, 1974

Faeces: As it turns out from the figures 1. and 2., the rate of faeces (FU) grows with the increase of food consumption (C). Expressed in the rate of consumption (FU/C):

Tr. nodulosus juv. 28—30. days 23—40 per cent
53—86. days 67—75 per cent
Tr. nodulosus adult . 46 per cent

P-ΔB relation: Of the two parameters the change of biomass (B) is measurable, the value of production may be calculated from that:

$$P = \Delta B + E.$$

E — elimination, that is the weight of perished individuals. E was immeasurable in my experiments as the exuviae casted and the dead animals were eaten by the examined Isopods. (SAITO (1970) experienced the same.) I observed also a certain degree of cannibalism at juvenil populations several times. Namely that the companions begin to champ the soft parts of injured respectively casting and therefore nearly helpless animals, and they eat the whole animal at last. Because of the elimination the number of individuals decreases strongly — expecially in the initial time period. This function is shown by N_1 curve of fig. 4., which corresponds to the third type of survival curves established by SLOBODKIN (1962). The tendency of elimination at different initial number is an interesting observation. At lower initial number of individuals (at the same surface) the mortality is considerably less, it shows the adequate part of the curve of higher initial number. This refers to the fact, that the change in individual number is influenced by density dependent factors.

The individual weight-growth was measurable among the outward forms of production in laboratory populations. At juvenils the next relation can be done for the growth of biomass:

$$y = \frac{K}{1 + e^{a+bx}}$$

The growth of biomass is logistic, which corresponds to the hypotetic model of PETRUSEWICZ and MACFADYEN (Fig. 4. B_1).

Energetics: The calorific values of *Tr. nodulosus:*

animal	:3,19 gcal/mg
ash free	:4,378 gcal/mg
faeces	:3,666 gcal/mg
food	:4,382 gcal/mg

During the drying needed for the calorimetry, knowing the living weight of animals, the average dry material — and ash-content can be given:

dry material content in p.c. of living weight	:30,01
ash content in p.c. of dry weight	:31,68

Data with similar type are published by GERE (1962), he gives the water content of the animals percental. The dry material content can easily be counted from this. The dry material content of different Iso- and Diplopods derive from his data are between 31,39—35,99 per cent.

References

DUDICH E., BALOGH J. és LOKSA I. (1952): Erdőtalajok ízeltlábúinak produkciós-biológiai vizsgálata (Production-biological investigations of Arthropods living in forest soils). — MTA Biológiai és Agrártudományi Osztálya közleményei *3*, 505—532.

GERE G. (1956a): The examination of feeding biology and the humicative function of Diplopoda and Isopoda. — Acta Biol. *6*, 257—271.

GERE G. (1956b): Erdei avarfogyasztó Diplopoda és Isopoda fajok humifikációs szerepének vizsgálata növénynevelési módszerrel (The examination of humicative role of Isopods and Diplopods feeding on forest-litter). — Áll. Közl. *45*, 71—77.

GERE G. (1962): Nahrungsverbrauch der Diplopoden und Isopoden in Freilandsuntersuchungen. — Acta Zool. Acad. Sci. Hung. *8*, 385—415.

HUBBEL, S. P., SIKORA, A. and PARIS, O. H. (1965): Radiotracer, gavimetric and calorimetric studies of ingestion and assimilation rates of an Isopod. — Health Phys. *11*, 1485—1501.

MACFADYEN, A. (1967): Methode of investigations of productivity of invertebrates in terrestrial ecosystems. — Secondary productivity of terrestrial Ecosystems (ed. K. Petrusewicz) Warszawa—Krakow.

MCBRAYER, J. F. and REICHLE, D. E. (1971): Trophic structure and feeding rates of forest soil invertebrate populations. — Oikos *22*, 381—388.

PARIS, O. H. (1965): Vagility of P^{32}-labelled isopods in grassland-ecology. — Ecol. *46*, 635—648.

PARIS, O. H. and PITELKA, F. A. (1962): Population characteristics of the terrestrial isopod *Armadillidium vulgare* in California grassland. — Ecol. *43*, 229—248.

PARIS, O. H. and SIKORA, A. (1965): Radiotracer demonstration of isopod herbivory. — Ecol. *46*, 729—734.

PETRUSEWICZ, K. (1967a): Concepts in studies on the secondary productivity of terrestrial ecosystems. — Secondary productivity of terrestrial ecosystems (ed. K. PETRUSEWICZ), 17—50.

PETRUSEWICZ, K. (1967b): Suggested list of more important concepts in productivity studies (definitions and symbols). — Secondary productivity of terrestrial ecosystems (ed. K. PETRUSEWICZ), 51—58. Warszawa—Krakow.

PETRUSEWICZ, K. and MACFADYEN, A. (1970): Productivity of terrestrial animals. — IBP Handbook, No. 13.

REICHLE, D. E. (1967): Radioisotope turnover and energy flow in terrestrial isopod populations. — Ecol. *48*, 351—366.

SAITO, S. (1965): Structure and energetics of the populations of Ligidium japonicum (Isopoda) in a warm temperate forest ecosystem. — Jap. J. of Ecol. *15*, 47—55.
SAITO, S. (1969): Energetics of isopod populations in a forest of central Japan. — Res. Popul. Ecol. *11*, 229—258.
SLOBODKIN, L. B. (1962): Growth and regulation of animal populations. — New York.
STACHURSKY, A. (1972): Population density, biomass and maximum natality rate and food conditions in Ligidium hypnorum L. (Isopoda) — Ekol. Pol. XX. *19*, 185—198.
STACHURSKY, A. (1974): Stabilization mechanism of energy transfer by Ligidium hypnorum (Cuvier) (Isopoda) population in alder wood (Carici elongatae-Alnetum). — Ekol. Pol. *22.1*, 3—29.
WHITE, J. J. (1968): Bioenergetics of the woodlouse Tracheoniscus rathkei Brandt in relation to litter decomposition in a deciduous forest. — Ecology *49*, 694—704.
WIEGERT, R. and EVANS, F. G. (1967): Investigations of secondary productivity in grasslands. — Secondary productivity of terrestrial ecosystems (ed. K. PETRUSEWICZ). Warszawa—Krakow.

Address of the author:
Dr. ERZSÉBET H. HORNUNG
Department of Zoology A. J. University,
H-6701 Szeged, P. O. Box 428 Hungary

Acta Biologica Szeged. 27 (1—4). pp. 209—213 (1981)

DATA ON THE OXIGEN CONSUMPTION OF ISOPODA AND DIPLOPODA SPECIES

ERZSÉBET H. HORNUNG

Department of Zoology, Attila József University, Szeged

(Received September 15, 1980)

Abstract

Examining the dependence of respiration of *Trachelipus nodulosus* C. L. KOCH, *Porcellio scaber* LATR. Isopods and of *Chromatoiulus unilineatus* L. Diplopod species on temperature related to body size with Warburg's technique can be determined that the rise of temperature (between 15—30 °C, $\mu l\ mg^{-1}\ h^{-1}$) — in accordance with the ecological demands of species—affects the respiration of *Ch. unilineatus* the least.

The respiration of *Tr. nodulosus* is also adapted to the environmental circumstances with higher temperature, while that of *P. scaber* is changing mostly with the temperature. The connection of body weight and individual oxygen comsumption is described by a so called "saturation curve" (Fig. 1b).

Introduction

The knowledge of energy emitted by the respiration is necessary to the explanation of ecological role, production relations of living organisms. Such investigations were carried out by SAITO (1965, 1967, 1969) at the macrodecomposer Isopod and Diplopod groups in the species *Japonaria laminata armigera* (Diplopoda), *Ligidium japonicum, Armadillidium vulgare, Porcellio scaber* (Isopoda). The body size of individuals and the environmental temperature were considered using Warburg's technique. REICHLE (1967) proved with isotope technique, that the value of oxygen consumption measured in laboratory is about 1,4 times lower than that of the animals moving in their natural environment. STACHURSKY (1974) examining the Isopod *Ligidium hypnorum* stated, that the quantity of oxygen respired is in exponential relation to the living weight of the individuals. NEWELL et al. (1974) examined the factors influencing the oxygen consumption of *Porcellio scaber* Isopod species using Gilson Differential Respirometer at different temperatures, considering the activity of the animals.

The aim of this work was to examine the fundamental relations to body size and to temperature among the factors influencing the respiration at three species common in our country.

Materials and Methods

Manometric calibrated Warburg respirometer was applied for respiration measures. The volumes of manometric chambers were about 15 ml. 20 per cent KOH served for occlusion of CO_2 expired by the animals. The chambers were kept in waterbath with constant temperature. Control chambers without animals were used for correction the possible temperature fluctuations. 1—1 animal was placed in every chamber on wet filter papers. So it was attainable that the animals stayed in rest and their activity didn't influence their oxygen consumption. As physiological condition has also influence on respiration, adult individuals of intercasting state were used for measurements. They had been kept previously in laboratory at least for one week. The species used for the measures were *Trachelipus nodulosus* C. L. KOCH, *Porcellio scaber* LATR. Isopods and *Chromatoiulus unilineatus* L. *Diplopod* species. The period of measures was 3—4 hours, within of which the oxygen consumption was recorded in every 20 minutes. 120 measurements were made, using 5—10 parallels with 80 animals of different weights. The living and dry weight of the investigated animals was measured before and after the experiments. The results are given in $\mu l \ h^{-1} \ mg^{-1}$ dry weight.

Results and discussion

The respiration measurements of populations can not be measured in field conditions, but the data determined in laboratory can not be extended to natural circumstances. The daily activity, the relation of activity and respiration, the relation between respiration and temperature, sex have to be taken into consideration. Respiration is reciprocally proportional to the body weight. The respiration rate related to the body weight is a hyperbolic function (Fig. 1). The constant parameters and the forms of these curves depend also on the temperature. The data of functions with form $y=a+b\frac{1}{x}$, can be seen in tables 1. 2. 3.

Table 1. Trachelipus nodulosus

°C	a	b	r	p
15	−0.022	2.0223	0.916	<0.02
20	0.0538	6.328	0.929	<0.1
25	0.12	29.63	0.956	<0.001
30	0.278	10.499	0.965	<0.01

Table 2. Porcellio scaber

°C	a	b	r	p
15	−0.099	6.076	0.946	<0.02
25	0.403	5.314	0.631	>0.1
30	2.609	16.651	0.536	>0.1

Table 3. Chromatoiulus unilineatus

°C	a	b	r	p
20	0.0216	0.473	0.856	<0.1
25	0.0248	1.254	0.781	<0.1
30	0.18	1.21	0.441	=0.1

The rise of respiratory curve of the two investigated Isopod species is higher than that of the Diplopod species. The consumption plotted against temperature results exponential curves (Fig. 2. 3.4). The figures show the oxygen consumption of individuals with the same body weight as a function of temperature.

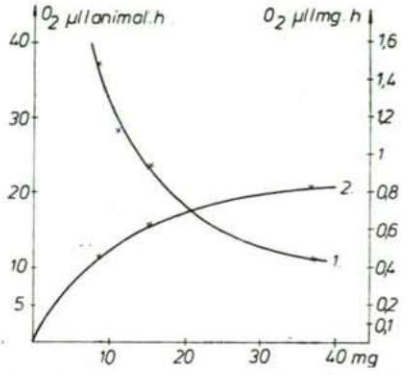


Fig. 1. (a) The dependence of oxigen consumption on body weight of individuals investigated ($\mu l \times mg^{-1} \times h^{-1}$) and
(b) the oxygen consumption of the animals of different weights (μl/animal$\times$h)
(*Trachelipus nodulosus*, 30 °C).

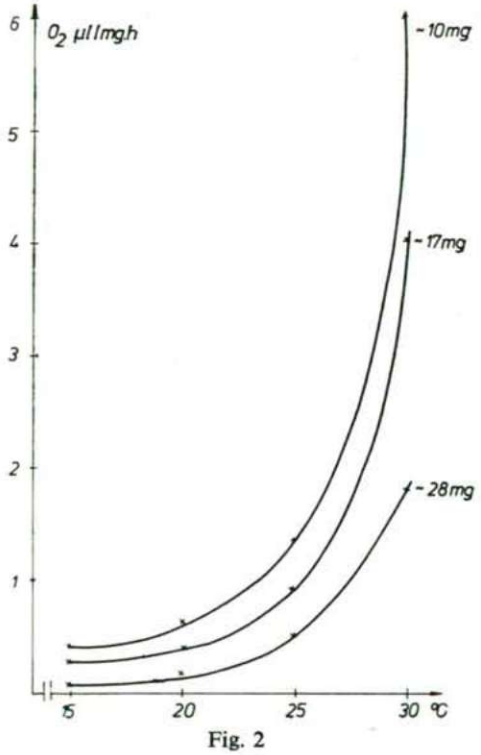


Fig. 2

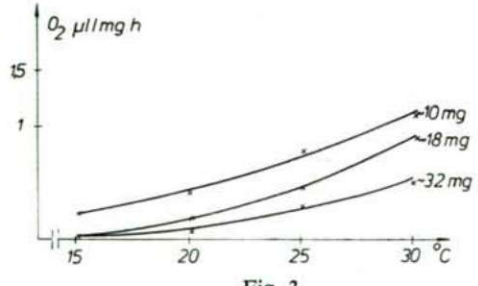


Fig. 3

Fig. 2—4. The oxygen consumption of individuals with same weights at different temperatures:
Porcellio scaber (Fig. 2)
Trachelipus nodulosus (Fig. 3)
Chromatoiulus unilineatus (Fig. 4).

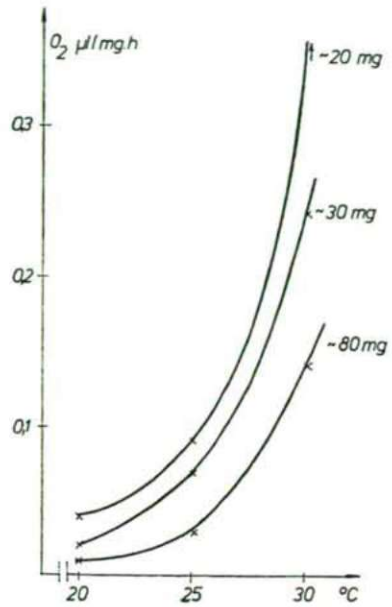


Fig. 4

Comparing the respiration of the species *P. scaber* and *Tr. nodulosus* it turns out that the respiration intensity of the latter one depends on the environmental temperature much less and it's respiration curve is considerable plattened. This can be explained with the different habitats and ecological demands of the above mentioned species. While the *P. scaber* generally lives in cellars, glass-houses, gardens, open woodlands, under stones, the *Tr. nodulosus* can be found on open grasslands. It is a xerophil species exposing to great temperature fluctuations. The respiration of *Ch. unilineatus* is even less influenced by the rise of temperature that can be explained with its ecological demands. It lives on dry grasslands, in acacia groves and is generally distributed, wide spead in the Great Hungarian Plain.

JENSEN and NIELSEN (1975) got exponential functions similar to the 2—4. figures also for poikilotherm insect imagos. The form of their equation:

$$\lg y_w = 0{,}0491t - 0{,}9111.$$

It is supposed, that these exponential curves are saturated and so form Verhulst logistic curves at higher temperature values as it was established by GALLÉ (1978) on ants and CSOKNYA and HALASY (1975) on *Palingenia longicauda* OLIV. (Ephemeroptera). NEWELL et al. (1974) wrote also about such curves at extrem high temperatures examining *P. scaber*. The temperature values that are felt extrem by the single species adapted to divergent conditions can be different. For instance the respiration rate of *P. scaber* is strongly raised by the temperature at 20—25 °C, which — since it doesn't mean physiological threshold of temperature to increase the rate of metabolism — causes much less increase in the oxygen consumption rate of *Tr. nodulosus* and *Ch. unilineatus* having thermophile niche center.

References

CSOKNYA, M. and HALASY, K. (1975): Experiments for determining the oxigen consumption of nymphs of *Palingenia longicauda* (Ephemeroptera). — Tiscia (Szeged) *10*, 51—54.

GALLÉ, L. JR. (1978): Respiration as one of the manifestations of the group effect in ants. — Acta Biol. Szeged. *24*, 111—114.

JENSEN, T. F. and NIELSEN, M. G. (1975): The influence of body size and temperature on worker ant respiration. — Nat. Jutl., *18*, 21—25.

NEWELL, R. C., WIESER, W. and PYE, V. I. (1974): Factors affecting oxigen consumption in the woodlouse *Porcellio scaber* LATR. — Oecologia (Berlin), *16*, 31—51.

REICHLE, D. E. (1967): Radioisotope turnover and energy flow in terrestrial ispod populations. — Ecology, 48. *3*, 351—366.

SAITO, S. (1965): Structure and energetics of the populations of *Ligidium japonicum* (Isopoda) in a warm temperate forest ecosystem. — Jap. J. of Ecol. 15. *2*, 47—55.

SAITO, S. (1967): Productivity of a high and low density populations of *Japonaria laminata armigera* (Diplopoda) in a warm-temperate forest ecosystem. — Res. Popul. Ecol. IX. *2*, 153—166.

SAITO, S. (1969): Energetics of Isopod populations in a forest of central Japan. — Res. Popul. Ecol. XI. *2*, 229—258.

STACHURSKY, A. (1974): Stabilization mechanism of energy transfer by *Ligidium hypnorum* (CUVIER) (Isopoda) population in alder wood *(Carici-elongatae-alnetum)*. — Ecol. Pol. *22*, 3—29.

Address of the author:
Dr. ERZSÉBET H. HORNUNG
Department of Zoology A. J. University
H-6701 Szeged, P. O. Box 428 Hungary

Acta Biologica Szeged. 27 (1—4), pp. 215—221 (1981)

THE DESCRIPTION AND INCIDENCE OF THE STAFNE IDIOPATHIC BONE DEFECT IN SIX AVAR PERIOD POPULATIONS

M. FINNEGAN and ANTÓNIA MARCSIK

Osteology Laboratory, Department of Sociology, Anthropology, and Social Work of Kansas State University, Manhattan, Kansas, USA, and Department of Anthropology, Attila József University, Szeged, Hungary

(Received September 10, 1980)

Abstract

The high incidence of the Stafne Defect found in Avar materials from Hungary particularly the sample of Fehértó-A, has led to an analysis. The material is described in terms of the size and shape of the defect, including its location in the mandible, and the age and sex of the individuals displaying this defect. The conclusion of the present authors is that this defect is developmental and most probably the result of some pressures caused by the sublingual or submandibular gland and that it is not due to trauma as it is easily distinguished from traumatic or hemorrhagic cysts of the mandible as pointed out by many authors.

Introduction

Since the first report of the idiopathic defect of the mandible by STAFNE (1942) some 250 cases of this kind of defect have been reported in the clinical literature. The review of the clinical and osteological literature dealing with this defect is in our earlier study (FINNEGAN and MARCSIK, 1980). Most of these clinical cases have been studied from radiographic evidence or operative surgery with supporting histological examination. Although the etiology of this defect still evades us, a number of authors have projected etiologies as seen in various synonyms used as descriptive of this defect: static bone defect or cavity (BERNSTEIN et al., 1958; GLAHN and RUD, 1962; MENZEL, 1969) aberrant salivary gland defect (AMARAL and JAKOBS, 1961; HAYES, 1961; RICHARD and ZISKING, 1957), idiopathic bone cavity (SENNO et al., 1969; THOMA, 1942), ectopic salivary gland of the mandible (FORREST, 1974; SUGARAWA, 1972) lingual mandibular bone concavity (ALVARES et al., 1969; OLECH and ARORA, 1961), and latent bone cyst (FORDYCE, 1956; NISHIJIMA et al., 1969; YOSHIGA et al., 1973).

The first study done on maserate specimens in observation of the Stafne idiopathic bone defect was reported by Harvey and Noble in 1968. More detailed studies with larger sample sizes were then conducted by KAY (1974) with a number of individual defects noted in small series by a number of authors (FINNEGAN, 1978; FINNEGAN and WITTY, 1977; KEITH, 1973, 1975; LANGLAIS et al., 1976).

The purpose of this paper is to present the descriptive characteristics of the idiopathic bone defect of the mandible in ten cases derived from Avar period material.

Materials and Methods

In July of 1977 data was collected on 300 crania from six Avar period populations housed in the Department of Anthropology, Attila József University, Szeged, Hungary. During the analysis of non-metric traits on this basic data sample set, a number of Stafne idiopathic bone defects were noted. At the end of the data collection it was noted that ten STAFNE idiopathic bone defects had been observed (295 mandibles) and that the frequency for this defect was exceedingly large relative to either or other archaeological literature (FINNEGAN and MARCSIK, 1980).

When found, each defect was recorded for the age, sex, size, and side of the mandible and other non-metric traits associated with that mandible (mandibular foramen, mental foramen, mandibular torus and mylohyoid bridge, (FINNEGAN and MARCSIK, 1979). Additionally, a frequency was generated for the number of defects in each of the six sample populations. The basic data was followed up with a photograph and roentgenogram of each defect.

Case Description of the Avar Period Material

Case 1: An adult male (5931), age 50 to 60 years, from the Kunszállás sample. The defect is located on the left side below the space between M2—M3 near the inferior border. It is more or less circular in form measuring 10 mm in diameter with a smooth floor. Although this defect is easily noted in the maserate specimen, the borders of cordical bone are rather beveled and diffuse and is all but lost in the *x*-ray.

Case 2: A male individual (6860), 40 to 50 years of age, from the Mélykút—Sáncdűlő sample. The defect is found on the right side between M3 and the angle, it is circular, and the floor of the defect is smooth. It is 10 mm in diameter and ca. 5 mm deep from the surrounding bone. The posterior margin of this defect is somewhat better developed than the anterior margin, with the x-ray showing a well developed posterior margin and a diffuse anterior margin. (Fig. 1, 7)

Case 3: A female (1775), age 30 to 40 years, from the Fehértó-A sample. The defect is located on the left side below the M3 space near the inferior border. The defect is well defined and has a cor-

Fig. 1. Mélykút-Sáncdűlő (6860)

Fig. 2. Fehértó-A (1679)

Fig. 3. Fehértó-A (2434)

Fig. 4. Fehértó-A (1869)

rugated floor measuring 8×4×ca. 3 mm deep. Anterior to this defect, as seen on the maserate specimen, is another defect which is probably due to erosion of the bone, which often happens in archaeological material. Anterior to this, and below the space between M2—M1, is an erosion area, involving the cortical bone, showing a tumor or eroded underlying hemorrhagic cyst. This shows up quite well in the x-ray as does another radiolucent area more anterior in the mandible. The Stafne defect itself barely shows as a radiolucent area near the inferior border of the mandible.

Case 4: A female (1679), age 30—35 years, from the Fehértó-A sample. The defect is located below the M3 space and measured 10×6 mm, and is at the inferior border of the mandible. The floor of the defect displays both smooth and granular bone. (Fig. 2.) The x-ray shows a well defined border superiorly, anteriorly and posteriorly, but the inferior border is quite diffuse and coíncident with the inferior border of the mandible.

Case 5: A male individual (2434), age 50 to 60 years, from the Fehértó-A sample. The defect in this individual is found on the right side below the M3. It measures 25×8 mm and is bilobed, conjoined, and the floor of the defect is granular in both lobes. The posterior portion of this defect is quite definitive, becoming beveled and more diffuse as it moves anteriorly. The borders seem sclerotic and are well defined in the x-ray. (Fig. 3, 8)

Case 6: A male (1869), 40 to 45 years of age, from Fehértó—A sample. This defect is located on the right side of the mandible below the M1—M2 space. It measures 15×8 mm and the floor of the defect varies from smooth to granular and in some parts the granular-corrugated nature of the floor appears stellate. (Fig. 4) All borders are fairly diffuse and the interior of the defect seems composed of well developed cortical bone which is radio-opaque and does not allow the defect to show up well on the x-ray.

Fig. 5. Fehértó-A (1725)

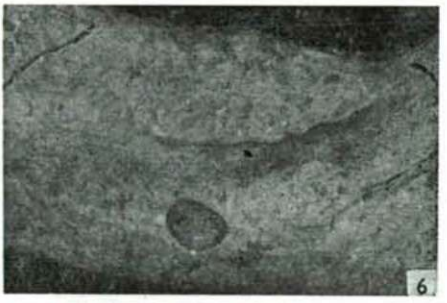


Fig. 6. Szeged-Kundomb (836)

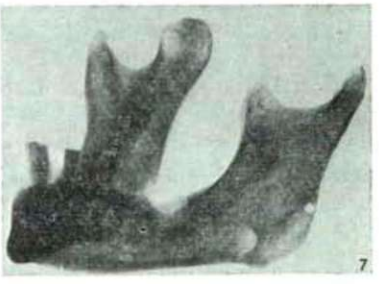


Fig. 7. Mélykút-Sáncdűlő (6860) x-ray picture

Case 7: A male (1725), age 35 to 45 years, from the Fehértó-A sample. The defect in this individual is found on the left side below M2. It is 20×7 mm and has a corrugated floor. (Fig. 5) The sides of the defect are somewhat beveled and therefore diffuse in the x-ray, but the defect is deep enough and the floor covering light enough that is shows up well on the x-ray.

Case 8: A male (1808), age 40 to 50 years, from the Fehértó-A sample. This individual displays a defect on the right side of the mandible below M3. It measures 8×5 mm and has a granular-corrugated floor. At the inferior border of this defect there is good definition, but because of the beveled and diffuse nature of the defect anteriorly and superiorly this defect cannot be seen in the x-ray.

Case 9: A male individual (755), age 55 to 65 years, from the Szeged—Kundomb sample. This defect is found on the right side and is bilobed to the point where two separate defects can be noted. The anterior defect found below M2 near the inferior border of the mandible measures 9×5 mm and the second defect located posteriorly 10 mm has major and minor axises of 5 and 3 mm. In each ca the defect lies close to the inferior border and the floor contents of each defect is granular, corrugated and irregular. Again, this defect, although it is well displayed on the maserate specimen, shows borders diffuse enough and floor dense enough, that the defect does not show in the x-ray.

Case 10: A male (836), age 30 to 35 years, from the Szeged—Kundomb sample. The defect in this individual is located on the right side below M2. The borders are well defined and the defect measures 8×5 mm. The floor of the defect is granularcorrugated. Although this defect is small the borders are adequately defined and the defect can be seen on associated x-rays. (Fig. 6, 9)

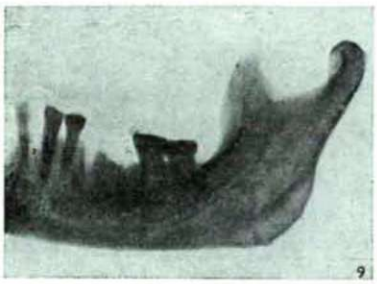


Fig. 8. Fehértó-A (2434) x-ray picture

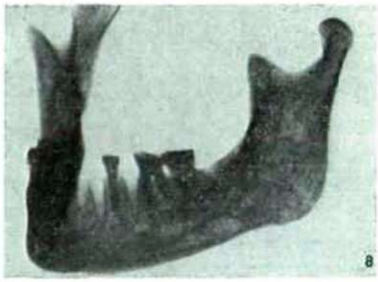


Fig. 9. Szeged-Kundomb (836) x-ray picture

Results

Considering our earlier study (FINNEGAN and MARCSIK, 1980) and this study the location of the Stafne idiopathic bone defect is usually found below the M3 or between the M3 and the angle of the mandible. It appears that as the location of the defect moves anteriorly the frequency of cases falls off almost in direct proportion, with six cases below M2, four cases below the space M1—M2, two cases below M1 and one case found below PM2. (It must here be noted that the defect below PM2 from Finnegan's Smithsonian data might well be an anterior defect, although the morphology of this particular defect agrees with Stafne idiopathic defect located more posteriorly on the mandible, the location itself is in the region which starts the incidence of anterior mandibular defects.).

In total 59 defects were found in the literature search and actual observation of mandible in this study. The total number of mandibles considered was 5519 which shows an incidence frequency of the Stafne defect of 1.069% based on the mandible. However with the defect occurring either on the left or the right side, or bilaterally, the frequency becomes .5345% defects per side of mandible.

With respect to sides, we find that the defect is more frequent on the left than on the right. With respect to sex dimorphism we find the males display the STAFNE idiopathic bone defect more often than the females.

Discussion

As pointed out above, a number of researchers have suggested various etiologies for the Stafne idiopathic bone defect. The conclusion of the present authors is that this defect is developmental and most probably the result of some pressures caused by the sublingual or submandibular gland and that it is not due to trauma as it is easily distinguished from traumatic or hemorrhagic cysts of the mandible as pointed out by many authors (FRIDMAN, 1964; GUALDI et al., 1971; HOREJS and PAVEK, 1972; KILLEY, 1963; MOSS and LEVEY, 1966; PHEMISTER and GORDO, 1926; WHINERY, 1955).

HARVEY and NOBLE (1968) suggest that the oldest known case of the Stafne defect is from Tennessee dating 750—500 B.C. We are now aware of two older finds one female skeleton dated by radiocarbon to 1600 years B.C. (material is discussed by BASS and HEAD (1974) and the oldest STAFNE defect on record is that from a male individual from the Early Bronze II age of Jordan, radiocarbon dated to 2624 B.C. (SI—2499) as reported by FINNEGAN (1978).

The size, shape, and location of the STAFNE idiopathic bone defect as seen in both archaelogical material and clinical cases suggest that they are developmental and might follow some other prescribed course of development than normally seen in terms of early developmental defects.

Additionally, a number of mandibles, particularly in the archaeological literature, show bilateral development with one side of the mandible displaying better development than the other side of the mandible. Indeed, the possibility of two defects on the same side of a mandible showing differential development has been noted by FINNEGAN (1977). From the clinical reports we only find one Stafne idiopathic bone defect that histologically produced contents which may be considered pathological in nature (SIMPSON, 1965).

With this low incidence of pathology and not knowing if the pathological entity found was directly caused by the Stafne idiopathic bone defect we must suggest that in the majority of cases (FINNEGAN and MARCSIK, 1980) the STAFNE idiopathic bone defect is not pathological in nature.

As shown by some of the archaeological material the STAFNE idiopathic bone defect can be seen on the dry maserate specimen, but not in an x-ray of the same specimen. The primary reason for this is that the defect has not developed far enough to show a definite margin of normal or increased bone density with a depressed floor showing a more radiolucent picture for diagnosis. This suggests that in the clinical literature many Stafne idiopathic bone defects would be found except they have not developed to the extent of showing up on panoramic or other x-ray techniques. With various new techniques in radiography and sialography these bone defects could probably be found in more clinical cases. However, if the defect does not show up on a general panoramic x-ray these further x-ray techniques would probably not be undertaken (JOHNSON, 1970; PHILLIPS and SHAWKAT, 1973; STAFNE, 1953; UEMURA et al., 1976).

The etiology of the Stafne idiopathic bone defect might stand a better chance of analysis if more information were supplied with the clinical case studies and the archaeological studies of this defect. In the future the information we should like to receive in order to better document the incidence of the Stafne idiopathic bone defect would

be the following: age, sex, race, size, side, and provenience of the sample, other non-metric traits associated with the defect, the condition of the dentition, and other pathological evidence either from the mandible or maxilla and the remainder of the skeleton as well. If indeed we had a large enough sample with all of this information we might then be able to make some association with this defect and the general health of the individual or show the increased incidence of the defect in various populations which may allow study of the genetic or nutritional basis of the defect based on the environment of the populations under study.

Conclusions

The word conclusion to head this section may well be somewhat premature. We suggest no "conclusions". However, what we have done is shown the incidence, age, sex, size, location and side relationships of the Stafne idiopathic bone defect and the fact that it can be readily distinguished from other pathological entities of the mandible. We have also shown that the sample populations from the Avar period in Hungary have a much higher incidence than reported elsewhere in either archaeological or clinical literature. We feel that the Stafne idiopathic bone defect, in light of the above discussion, warrants more research into the behavior and the exact developmental stages of this defect. While it is too early to suggest that this defect is genetic or due to nutritional deficiencies we think that this material lends itself to these possibilities and further research should be done in trying to determine the exact etiology of this bone defect.

References

ALVARES, O., OLECH, E. and SILVERGLADE, L. B. (1969): Lingual mandibular bone cavity concomitant with a dentigerous cyst. A clinical and histological report. — Oral Surg. *27*, 252—256.

AMARAL, W. J. and JACOBS, D. S. (1961): Aberrant salivary gland defect in the mandible. Report of a case. — Oral Surg. *14*, 748.

BASS, W. M. and HEAD, J. H. (1974): Human Skeletal Material From an Archaic Kansas Site (14CF330). — Manuscript, Kansas State Historical Society, 1974.

BERNSTEIN, H. F., LAUNN, R. C. and POMMIJE, F. W. (1958): Static bone cavities of the mandible: Review of the literature and report of case. — J. Oral Surg. *16*, 46—52.

FINNEGAN, M. (1977): Osteological analysis of skeletal remains from the Chester Reeves Mound (23CL108), A Steed-Kisker Mississippian Population. Appendix I, pp. 111—163, (In: Cultural Resources Survey of Smithville Lake, Missouri, Vol. 1 by P. J. O'Brien.) — U. S. Army Corps of Engineers, Kansas City District, November 1977.

FINNEGAN, M. (1978): A Report on the Osteology of Charnal House A—A—55, at Bab edh-Dhra' Cementery, Jordan, from the excavations in 1975. — Report to the Codirectors for the Expedition to the Southeast Dead Sea Valley, Jordan.

FINNEGAN, M. and MARCSIK, A. (1979): A non-metric examination of the relationships between osteological remains from Hungary representing populations of Avar period. — Acta Biol. Szeged. *25*, 97—118.

FINNEGAN, M. and MARCSIK, A. (1980): Anomaly or Pathology: the Stafne Defect as Seen in Archaeological Material and Modern clinical Pratice. — J. Hum. Evol. *9*, 19—31.

FINNEGAN, M. and WITTV, T. (1977): A seated burial and associated boatstone from northwest Kasas. — Plains Anthr. *22*, 23—35.

FORDYCE, G. L. (1956): Probable nature of a so-called latent hemorrhagic cysts of the mandible. — Br. Dent. J. *101*, 40—42.

FORREST, W. R. (1974): Ectopic salivary gland. — Oral Surg. Oral Med. Oral Path. *37*, 653—654.
FRIEDMAN, J. (1964): Ectopic sublingual Gland: Report of a case. — Oral Surg. Oral Med. Oral Path. *18*, 219—222.
GLAHN, M. and RUD, J. (1962): Statische Knochenkavitäten im Unter-Kiefer. — Quintessenz, *9*, 15—16.
GUALDI, C.—FRAVEGA, E.—CAMURATI, R. (1971): Le Cisti Lantenti Statiche della Mandibola. — Minerva Stomat. *20*, 120—124.
HARVEY, W.—NOBLE, H. W. (1968): Defects on the lingual surface of the mandible near the angle. — Br. J. Oral Surg. *6*, 75—83.
HAYES, H. (1961): Aberrant submaxillary gland tissue presenting as a cyst of the jaw. Report of a case. — Oral Surg. *14*, 313—316.
HOREJS, J.—PAVEK, V. (1972): Sialography of the submaxillary Gland in the diagnosis of a radiolucent area in the mandible. — J. Int. Assoc. Maxillo-Facial Radíol. 9—10.
JOHNSON, C. C. (1970): Analysis of panoramic survey. — Am. Dent. *81*, 151—154.
KAY, L. W. (1974): Some Anthropologic Investigations of interest to Oral Surgeons. — Int. J. Oral Surg. *3*, 363—379.
KEITH, K. D. (1973): The paleostomatology at the Moore site (34LF31), LeFlore County, Oklahoma. — Bull. Oklahoma Anthr. Society. *22*, 149—157.
KEITH, K. D. (1975): Anomalous Bone Defects of the Mandible. — The Connec. Tissue. *2*, 4—10.
KILLEY, H. C. (1963): Surgical management of some benign cysts of the jaws. — Brit. Dent. J. *114*, 9—20.
LANGLAIS, R. P., COTTONE, J. and KASL, M. J. (1976): Anterior and posterior lingual depressions of the mandible. — J. Oral Surg. *34*, 502—509.
MENZEL, H. J. (1969): Einige Überlegunaen zur Ätiologie der statischen Knochenhölen. — Dtsch. Lahnaerztl. L. *23*, 58—64.
MOSS, M. and LEVEV, A. C. (1966): The traumatic bone cyst: report of three cases. — J. Am. Dent. Assoc. *72*, 397—402.
NISHIJIMA, D., TOMOSAWA, M. and OHASHI, S. (1969): So-called latent bone cyst; a case report. — Jap. J. Oral Surg. *15*, 205—208.
OLECH, E. and ARORA, B. K. (1961): Lingual Mandibular bone cavity. — Oral Surg. *14*, 1360—1366.
PHEMISTER, D. B. and GORDON, J. E. (1926): Etiology of solitary bone cyst. — J. A m.Med. Assoc. *87* 1429—1433.
PHILLIPS, J. D. and SHAWKAT, A. H. (1973): A study of the radioaraphic appearance of osseous defects on panoramic and conventional films. — Oral Surg. Oral Med. Oral Path. *36*, 745—749.
RICHARD, E. L. and ZISKIND, J. (1957): Aberrant salivary gland tissue in mandible. — Oral Surg. *10*, 1086—1090.
SENNO, T., FUJI, H., MATSUZAWA, K. and SADAOKA, T. (1969): Stafne's idiopathic bone cavity: report of case. — Jap. J. Oral Surg. *15*, 124—127.
SIMPSON, W. (1965): A Stafne's mandibular defect containing a pleomorphiadenoma: report of a case. J. Oral Surg. *23*, 553—556.
STAFNE, E. C. (1942): Bone cavities situated near the angle of the mandible. — J. Am. Dent. Assoc. *29*, 1969—1972.
STAFNE, E. C. (1953): Value of roentgenograms in diagnosis of tumors of the jaws. — Oral Surg. Oral Med. Oral Path. *6*, 82—92.
SUGAWARA, T. (1972): Development defect of mandible containing salivary gland tissue: Case report. — J. Jap. Stomat. *21*, 406—407.
THOMA, K. H. (1942): Diagnosis and treatment of cyts and tumors of jaws. — New York J. Dent. *12*, 297—302.
UEMURA, S.—FUJISHITA, M.—FUCHIHATA, H. (1976): Radiographic interpretation of so-called developmental defect of mandible. — Oral Surg. Oral Med. Oral Path. *41*, 120—128.
WHINERY, J. G. (1955): Progressive bone cavities of the mandible. Oral Surg. *8*, 903—916.
YOSHIGA, N., TOMITA, R., FUYAMADA, H. and KAWAY, M. (1973): A case report of latent bone cyst including lymphatic tissue. — Jap. J. Oral Surg. *19*, 714—715.

Address of the authors:
Dr. M. FINNEGAN
Department of Sociology, Anthropology
of Kansas State University, Manhattan,
Kansas, USA
Dr. ANTÓNIA MARCSIK
Department of Anthropology,
A. J. University
H-6701 Szeged, P. O. Box 428. Hungary

Acta Biologica Szeged. *27* (1—4), pp. 223—227 (1981)

ÜBER DAS MENARCHEALTER VON MÄDCHEN AUS KOMÁROM

GY. FARKAS and JULIA NAGY

Lehrstuhl für Anthropologie der Attila József Universität, Szeged
(Zeit der Einreichung der Manuskripts: 31.7.1980)

Auszug

Die Verfasser haben vom 25. Februar bis zum 23. April 1980 die mit des status-quo-Methode gesammelten Menarcheangaben von 533 Mädchen aus der Stadt Komárom (Bezirk Komárom, Ungarn) mit 10,5 bis 16,5 Jahren bearbeitet. Der Median für die gesamte Stichprobe wurde auf 12,72 Jahre festgelegt. Die Änderungen des Medians wurden nach dem Beruf des Vaters und der Mutter, nach de Geschwisterzahl und nach der in der Geschwisterreihe eingenommenen Stelle der Befragten untersucht.

Es wurde festgestellt, dass die Töchter der Mütter, die physische Arbeit verrichten, später reifen, als die der Intellektuellen. Der Unterschied ist in Hinsicht auf den Beruf der Vaters klein und dem vorigen Kriterium entgegengesetzt. Mit der Erhöhung der Geschwisterzahl und der in der Geschwisterreihe eingenommenen Stelle erhöht sich der Wert des Medians auch.

Einleitung

Die Untersuchung der Menarche (erste Blutung, erste Menstruation) wurde in Ungarn in den letzten Jahrzehnten immer intensiver. Die Verfasser richten nämlich ihr Augenmerk über die Feststellung des Medians hinaus auch auf andere Gesichtspunkte. So erforschen sie auch den Zusammenhang der Naturfaktoren und der gesellschaftlichen Faktoren mit der Pubertätszeit (FARKAS, 1970, 1980).

Ziel dieses Berichtes ist, die Ergebnisse bezüglich der Untersuchung des Menarche — Medians bei den Mädchen einer transdanubischen Kleinstadt mit etwa 11 tausend Einwohnern mit Anspruch auf Datenlieferung zu veröffentlichen.

Methode

Die Datensammlung wurde in der Leitspanne vom 25. Februar bis zum 23. April 1980 mit der status-quo-Methode (mit einmaliger Befragung) durchgeführt. Die aus 533 Personen bestehende Stichprobe haben wir zuerst in Altersgruppen nach Halbjahren aufgeteilt, später aber haben wir mit Hilfe des früher schon verwendeten numerischen Verfahrens (FARKAS, 1975), das mit dem Ergebnis der Probitanalyse mit einer Genauigkeit von einer Dezimalstelle übereinstimmt, den Median errechnet. Wir haben den arithmetischen Durchschnitt ($\bar{x}$), die Streuung des Medians (s_{Me}) sowie das Interwall des Umfangs 1,96 s bestimmt. Über die erwähnten Parameter informiert uns die Tabelle 1.

Tabelle 1. Menarcheparameter von Mädchen aus Komárom

Parameter Untersuchungskriterium	n	Me	$\bar{x}$	s_{Me}	$Me \pm 1{,}96.s_{Me}$
Ganze Stichprobe	533	12.72	12.75	0.078	12.57—12.87
Nach dem Beruf des Vaters:					
Ganze Stichprobe	423	12.78	12.78	0.089	12.61—12.95
Physische Arbeit Verrichtende insgesamt	271	12.68	13.06	0.173	12.34—13.02
Physische Arbeit Verrichtende in der Industrie	147	12.64	13.03	0.196	12.26—13.02
Physische Arbeit Verrichtende — anderweitig	124	12.72	13.32	0.363	12.01—13.43
Intellektuelle	152	12.70	12.54	0.159	12.39—13.01
Nach dem Beruf der Mutter:					
Ganze Stichprobe	422	12.77	12.82	0.090	12.59—12.95
Physische Arbeit Verrichtende	237	13.00	12.99	0.099	12.80—13.19
Intellektuelle	185	12.50	12.41	0.150	12.20—12.79
Nach der Geschwisterzahl:					
ohne Geschwister	82	12.54	12.38	0.060	12.42—12.66
eine Schwester oder ein Bruder	300	12.85	12.93	0.097	12.66—13.04
zwei Geschwister	89	12.92	12.69	0.286	12.36—13.48
Nach der in der Geschwisterreihe eingenommenen Stelle:					
— als erstes Kind geboren	282	12.69	12.64	0.112	12.26—13.12
— als zweites Kind geboren	185	12.81	13.03	0.154	12.51—13.11

Die Kriterien unserer Untersuchung waren wie folgt:

1. Wir haben den Median der gesamten Stichprobe festgestellt.
2. In bezug auf den Beruf der Mutter und — als zweites Kriterium — auf den des Vaters haben wir die Mädchen in Gruppen aufgeteilt und auf diese Weise erforscht, welche Werte der Median (die Reifungszeit) der Töchter von Eltern mit unterschiedlichen Berufen aufweist. Der Einordnung der Berufstypen haben wir die Nomenklatur des Zentralen Statistischen Amtes zugrundegelegt.
3. Wir haben den Median nach der Geschwisterzahl bestimmt.
4. Wir haben die Änderung des Medians nach der Stelle des befragten Mädchens in der Geschwisterreihe untersucht.

Ergebnisse

Der Median der gesamten Stichprobe beträgt 12,72 Jahre; dieser Wert ist etwa um 0,5 Jahre niedriger, als der Median Ungarns im Jahre 1963 (BOTTYÁN et. al., 1963), aber er liegt den in den letzten Jahren in Ungarn erhaltenen Werten sehr nahe.

Wir schreiben diese Änderung der sich auch bei der Reifungszeit durchsetzenden Akzeleration zu.

Auf die Änderungen nach dem Beruf der Eltern wurde in den letzten Jahrzehnten von vielen Verfassern in mehreren Ländern hingewiesen. So hat ŁASKA—MIERZEJEWSKA (1968, 1970) und MILICER (1968), bei polnischen, RICHTER (1973) bei deutschen, BODZSÁR aber (1975) bei ungarischen Mädchen die Beobachtung gemacht, dass die Töchter von Vätern und Müttern, die physische Arbeit verrichten, später reifen, als die der Intellektuellen.

Es stehen uns aber auch solche Angaben zur Verfügung, die der erwähnten Beobachtung widersprechen (BER—BROCINER, 1964; ROBERTS—DANN, 1967; ROBERTS—ROZNER—SWAN, 1971, ROBERTS, 1977), nach denen es nicht gelungen habe, zwischen dem Beruf der Eltern und der Reifungszeit ihrer Töchter einen Zusammenhang nachzuweisen.

Die letzte ungarische Analyse scheint — mindestens nach dem Beruf der Mütter — die Tatsache der Existenz eines Zusammenhangs zu bestätigen (FARKAS, 1980). Diese Beziehung ist aber bezüglich des Berufes der Väter nicht mehr eindeutig.

Diese Erfahrungen beweisen, dass das Problem einer weiteren Erforschung bedarf; dies hat uns dazu bewogen, auch bei Mädchen aus Komárom auf die Erforschung diese Zusammenhangs einzugehen.

Wie es aus Tabelle 1 ersichtlich ist, gibt es zwischen den Menarche—Medianwerten der Töchter von Vätern, die auf einem physischen Arbeitsgebiet tätig sind und denen der Töchter von Intellektuellen nur einen unbeträchtlichen Unterschied.

Aus dieser Abweichung folgt, dass die Pubertät — im Gegensatz zu unseren früheren Erfahrungen — bei den Töchtern von Vätern, die eine physische Arbeit verrichten, früher eintritt. In bezug auf den Beruf der Mütter haben wir ein ähnliches Ergebnis bekommen wie früher (FARKAS, 1980), d.h. die Töchter von Müttern, die einen geistigen Beruf ausüben, früher zur sexuellen Reife gelangen, als die Töchter der auf physischem Arbeitsgebiet tätigen Mütter.

Im Hinblick auf die Anzahl der Geschwister haben die Autoren über zweierlei Erfahrungen berichten können. Die meisten von ihnen sind zum folgenden Ergebnis gekommen: je grösser die Zahl der Geschwister in einer Familie ist, desto später tritt bei den Mädchen die Menarche ein (PETRI, 1935; SCOTT, 1961; SOENDEROP, WINTER and NEELSEN, 1961; TANNER, 1962; VALŠÍK, STUKOVSKY and BERNÁTOVÁ, 1963; VALŠÍK, 1965; GRIMM, 1966; ŠTUKOVSKY, VALŠÍK, BULAI and STIRBU, 1967; RICHTER, 1970, 1973; ROBERTS, ROZNER and SWAN, 1971; ROBERTS, 1977).

Auch die Forschungen in Ungarn können über ähnliche Ergebnisse berichten (EIBEN, 1972; BODZSÁR, 1975). Im letzten Jahrzehnt wird es von wenigen Autoren behauptet, dass sie keinen nachweisbaren Unterschied zwischen der Zahl der Geschwister und der Zeit der Menarche gefunden hätten (CARFAGNA, FIGURELLI and MATARESE, 1972).

Im Falle der Mädchen aus Komárom konnten wir diesen Zusammenhang, wegen des grossen Umfangs der Stichprobe, nur bei Mädchen untersuchen, die entweder keine, oder höchstens zwei Geschwister hatten. Wie es aufgrund der Tabelle festzustellen ist, erhöht sich der Median im geraden Verhältnis zur Zahl der Geschwister in der Familie. Hierbei müssen wir aber erwähnen, worauf schon von mehreren Verfassern hingewiesen wurde, (ROBERTS, ROZNER and SWAN, 1971; EIBEN, 1972; BODZSÁR, 1975), nämlich, dass diese Erhöhung nur bis zu einer Geschwisterzahl von 4—5 Kindern zu registrieren ist; im Falle einer Kleineren Geschwisterzahl ist wiederum eine Verringerung des Medianwertes zu betrachten.

Die in der Geschwisterreihe eingenommene Stelle (d.h. als wievieltes Kind das Mädchen in der Familie geboren wurde), kann den Wert des Medians gleichfalls beeinflussen, wie es schon in den früheren Veröffentlichungen in Ungarn erwähnt wurde (EIBEN, 1972; BODZSÁR, 1975).

Aus der von uns untersuchten Stichprobe ist es deutlich, dass der Median der erstgeborenen Mädchen niedriger ist, als der der zweitgeborenen.

Es steht uns fern, aufgrund einer Stichprobe von 533 Mädchen weitgehende verallgemeinernde Schlüsse zu ziehen, aber unsere Erfahrungen zeigen, dass die Untersuchung all dieser Fragen notwendig ist, weil die Annahme dieser Zusammenhänge in mehr Publikationen demonstriert wird als deren Ablehnung

Die endgültige Klärung dieser Fragen wird aber natürlich erst nach einer grossangelegten und gründlich geplanten Datensammlung möglich, die wir in der nächsten Zukunft bei ungarischen Mädchen nach unseren Vorstellungen anstellen möchten.

Die bewiesene oder scheinbare Tatsache der existierenden Zusammenhänge lenkt aber unsere Aufmerksamkeit auf jeden Fall darauf, dass man sie bei der sexuellen Aufklärung von Mädchen und bei der Beschäftigung mit Pubertierenden im allgemeinen in grösserem Masse berücksichtigen muss.

Schrifttum

BER, A. and BROCINER, C. (1964): Age of puberty in Israeli girls. — Fertility and Sterility *15*, 640—647.

BODZSÁR, É. (1975): Data to puberty of girls. — Humanbiol. Budapestinensis *3*, 174 pp.

BOTTYÁN, O., DEZSŐ GV., EIBEN, O., FARKAS GV., RAJKAI, T., THOMA, A. and VÉLI, GY. (1963): Age at Menarche in Hungarian Girls. — Ann. Hist.-nat. Mus. Nat. Hung. *55*, 561—572.

CARFAGNA, M., FIGURELLI, E., MATARESE, G. and MATARESE, S. (1972): Menarcheal Age of Schoolgirls in the District of Naples, Italy, in 1969—70. — Hum. Biol. *44*, 117—125.

EIBEN, O. (1972): Genetische und demographische Faktoren und Menarchealter. — Anthrop. Anz. *33*, 205—212.

FARKAS GY. (1975): A gyomai gyerekek testi fejlettsége és nemi érése. — Anthrop. Közl. *19*, 97—104.

FARKAS, GY. (1979): Die Grösse des Menarche-Medianwertes in Ungarn und seine Beziehung zu meteorologischen Angaben. — Ärztl. Jugkde. *70*, 275—281.

FARKAS, GY. (1980): Veränderungen des Menarche-Medianwertes nach dem Beruf der Mutter. — Ärztl. Jugkde. *71*, 62—67.

GRIMM, H. (1966): Grundriss der Konstitutionsbiologie und Anthropometrie. VEB Verlag Volk und Gesundheit Berlin, 13—145.

KSH. Statisztíkai nomenklaturák. Foglalkozások egységes osztályozási rendszere (Statistische Nomenklaturen. Die einheitliche Klassifizierung der Berufe).

ŁASKA-MIERZEJEWSKA, T. (1968): Wiek menarche dziewszat wiejskich z powiatow sanockiego i kronienskiego. — Przlg. Antr. *34*, 309—316.

ŁASKA-MIERZEJEWSKA, T. (1970): Effect of Ecological and Socio-Economic Factors on the Age at Menarche, Body Height and Weight of Rural Girls in Poland. — Hum. Biol. *42*, 248—292.

MILICER, H. (1968): Age at menarche of girls in Wroclaw, Poland, in 1966. — Hum. Biol. *40*, 249—259.

PETRI, E. (1935): Untersuchung zur Erbbedingtheit der Menarche. — Z. Morph. Anthr. *33*, 43—48.

RICHTER, J. (1970): Weitere Ergebnisse von Menarche-Untersuchungen in Görlitz. — Ärztl. Jugkde. *61*, 372—378.

RICHTER, J. (1973): Zur Akzeleration der Menarche Ergebnisse und Schlussfolgerunden aus Untersuchungen an Görlitzer Mädchen. — Ärztl. Jugkde. *64*, 268—280.

ROBERTS, D. F. (1977): The changing pattern of menarcheal age. — Growth and Development; Physique. Symp. Biol. Hung. *20*, 167—175.

ROBERTS, D. F. and DANN, T. C. (1967): Influences on menarcheal age in girls in a Welsh college. — Brit. J. Prev. Soc. Med. *21*, 170—176.

ROBERTS, D.F., ROZNER, L.M. and SWAN, A.V. (1971): Age at menarche, physique and environment in industrial north east England. — Acta Paediat. Scand. *60*, 158—164.

SCOTT, J. A. (1961): Report on the heights and weights (and other measurements) of school pupils in the country of London in 1959. London Country Council. (cit.: ŠTUKOVSKÝ et al, 1967.)

SOENDEROP, R., WINTER, K. and NEELSEN, U. (1961): Ueber den Zeitpunkt der Menarche. — Deutsch. Gesundheitsw. *16*, 1485—1489.

ŠTUKOVSZKÝ, R., VALŠÍK, J. A. and BULAI-STIRBU, M. (1967): Family size and menarcheal age in Constanza, Roumania. — Hum. Biol. *39*, 277—283.

TANNER, J. M. (1962): Wachstum und Reifung des Menschen. Stuttgart 49—51.
VALŠÍK, J. M. (1965): The Seasonal Rhythm of Menarche: a review. — Hum. Biol. *37*, 79—90.
VALŠÍK, J. M., ŠTUKOVSKÝ, R. and BERNÁTOVÁ, L. (1963): Quelques facteurs géographiques et sociaus ayant une influence sur l'age de la puberté. — Biotypologie *24*, 109—123.

Adresse der Verfasser:
Dr. GY. FARKAS
Anthropologisches Institut
der Attila József Universität,
H-6701 Szeged, Pf. 428. Ungarn
Dr. J. NAGY
Jókai Gymnasium,
H-2900 Komárom, Ungarn

Index